Technical training.
Product information.

I01 Chassis and Suspension

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BMW Group University
Technical Training
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BMW Service

General information

Symbols used

The following symbol is used in this document to facilitate better comprehension or to draw attention to very important information:

⚠

Contains important safety information and information that needs to be observed strictly in order to guarantee the smooth operation of the system.

Information status and national-market versions

BMW Group vehicles meet the requirements of the highest safety and quality standards. Changes in requirements for environmental protection, customer benefits and design render necessary continuous development of systems and components. Consequently, there may be discrepancies between the contents of this document and the vehicles available in the training course.

This document basically relates to the European version of left-hand drive vehicles. Some operating elements or components are arranged differently in right-hand drive vehicles than shown in the graphics in this document. Further differences may arise as the result of the equipment specification in specific markets or countries.

Additional sources of information

Further information on the individual topics can be found in the following:

- Owner's Handbook
- Integrated Service Technical Application.

Contact: conceptinfo@bmw.de

The information contained in this document forms an integral part of the technical training of the BMW Group and is intended for the trainer and participants in the seminar. Refer to the latest relevant information systems of the BMW Group for any changes/additions to the technical data.

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I01 Chassis and Suspension
Contents

I01 Chassis and Suspension

Contents

I01 Chassis and Suspension

1. Introduction

1.1. Models

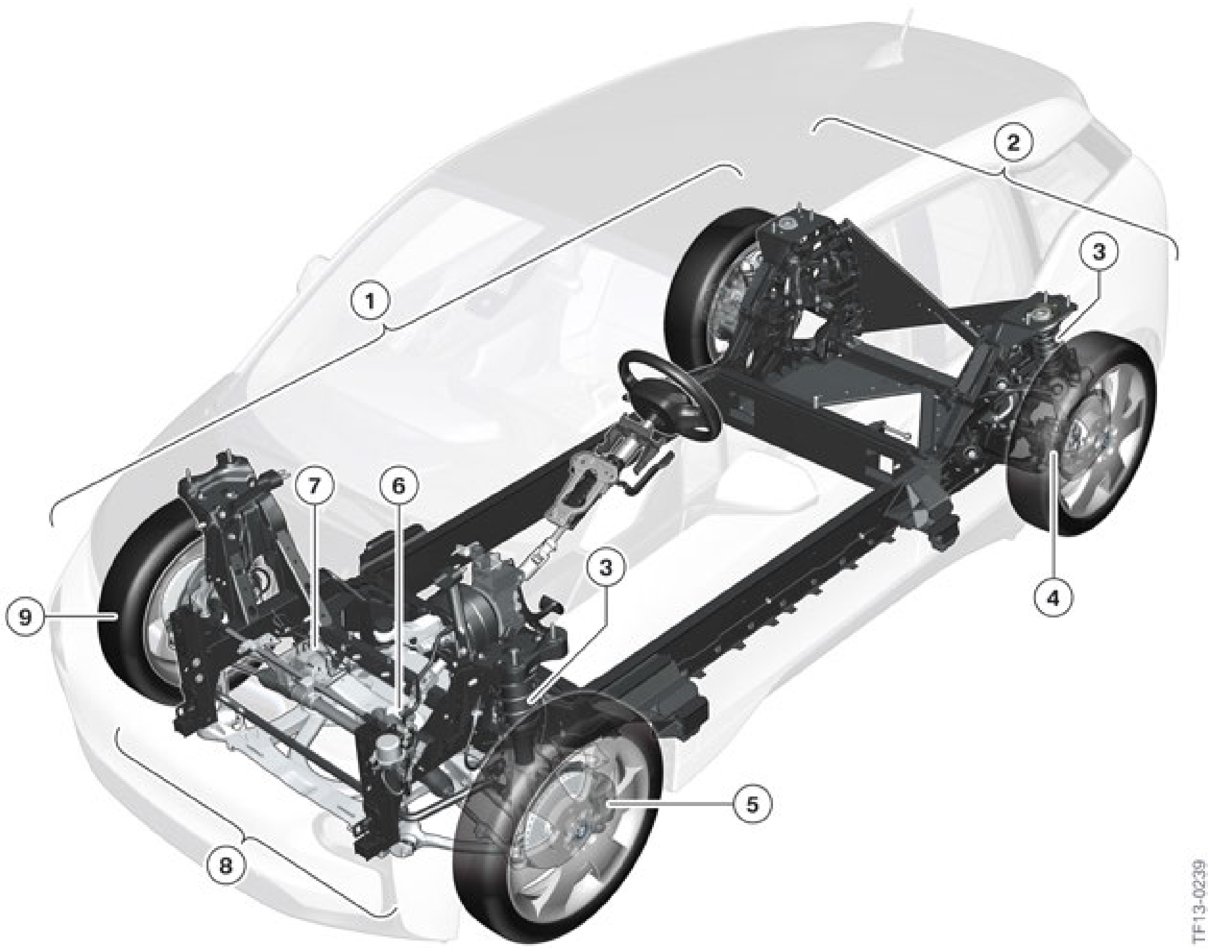
The development code of the described vehicle is I01, similar to the F30 development code, the model designation is BMW i3. The I01 is the first mass produced BMW vehicle to be designed purely for electric driving. The associated changes (compared to a conventional vehicle) are not only limited to the use of new materials or the electrical machine. The chassis and suspension area was also systematically adapted to the overall concept. This training information provides an overview of the chassis and suspension as well as the suspension control systems, of the I01.

Two different versions of the I01 are used:

- A purely electric vehicle referred to as BEV (without range extender)
- And an electric vehicle with range extender referred to as a REX.

A combustion engine, also referred to as a Range Extender, is used to extend the range of the vehicle. The REX converts the energy stored in the fuel into electrical energy with the assistance of a generator. The voltage produced is then stored in the high-voltage battery unit of the I01 and, if required, used to power the vehicle.

1.2. Overview of chassis and suspension



I01 chassis and suspension, complete overview

Index	Explanation
1	Drive module
2	Five-link rear suspension (HA5)
3	Suspension/dampers
4	Electromechanical Parking Brake (EMF)
5	Brakes
6	Electronic Power Steering (EPS)
7	Dynamic Stability Control (DSC)
8	Single-joint spring-strut-type front axle
9	RAD

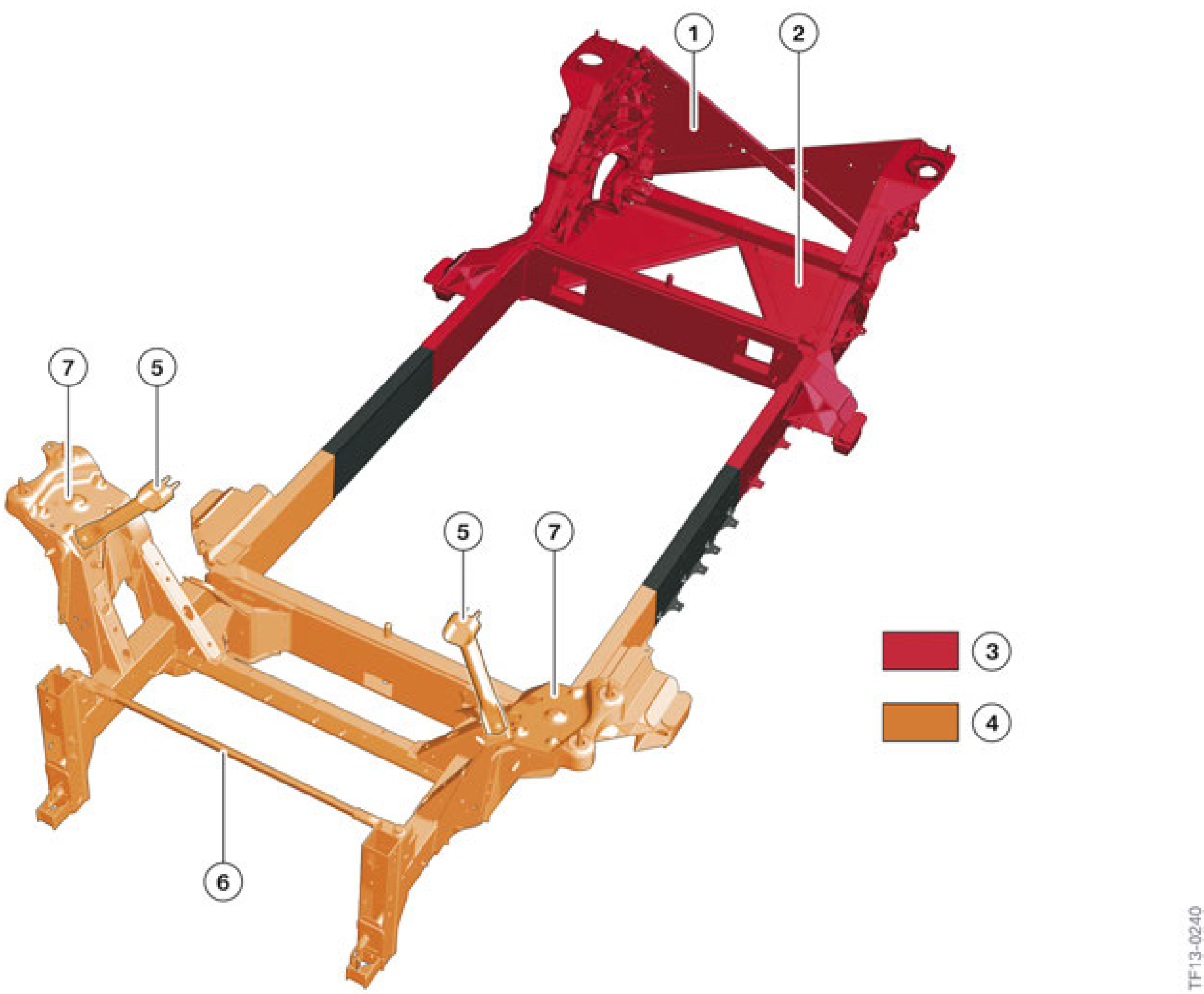
A significant difference when compared to current BMW vehicles is the omission of a unitary body. In the I01, the Drive module (1) constitutes the supporting structure that connects the various chassis and suspension components. The Drive module (1) is made of aluminium and is permanently

connected to the Life module which constitutes the passenger cell, among other things. This architecture has been chosen so that the large energy accumulator can be positioned optimally in the vehicle. The battery cells are fully integrated into the vehicle underbody and fill the entire central area of the Drive module (1); a favorable situation in terms of dynamic handling characteristics. This positioning guarantees optimum axle-load distribution and a low center of gravity.

The single-joint spring-strut-type front axle (8) of the I01 is in principle similar to the front axle of a E46. A five-link rear axle HA5 (2), similar to the HA5 of a F30, is used. As the vehicle has been designed for urban traffic, it has an extremely small turning circle which is no more than 9.9 m. For comparison: the turning circle of a E46 is 10.5 m.

The I01 features Electronic Power Steering (EPS) (6) and an electromechanical parking brake EMF (4) with additional functions. The Dynamic Stability Control (DSC) (7), that performs several additional tasks is the core of the brake system. Furthermore, the tire pressure monitoring (TPMS) has been further developed and, in terms of function and operation, differs from the TPMS systems used up till now.

1.3. Drive module



I01 Drive module

I01 Chassis and Suspension
1. Introduction

Index	Explanation
1	Cross brace
2	V-struts
3	Rear axle module
4	Front axle module
5	Strut braces
6	Strut
7	Spring strut dome

The front axle module (4) and rear axle module (3) are located at the Drive module. If damage occurs in the area of the front axle module or rear axle module, a structural repair of the relevant component can be carried out by a qualified BMW i Full Service outlet.

A strut (6), two strut braces (5) and the two spring strut domes (7) are located in the area of the front axle module. The strut which is made of high-strength steel helps protect the occupants in the event of a head-on post crash due to its particularly high strength. The strut braces help increase the transverse rigidity of the vehicle. This can counteract the distortion of the front axle module, which can occur when cornering for example. In the event of a crash, the strut braces stabilize the attachment points of the spring strut domes.

The V-struts (2) and cross-bracing (1) are located at the rear axle module. The purpose of these two strut sections is to increase the static and dynamic rigidity of the rear axle module. This prevents the camber and directional stability at the rear axle from being adversely affected.

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Observe that a test drive with disassembled strut brace, pole strut, V-strut or cross-bracing is **not** permitted due to the lack of reinforcement in the Drive module.

1.4. Technical data

The following table shows the technical data of the two versions of the I01 with and without range extender.

Designation	I01 without range extender	I01 with range extender
Wheel base	2570 mm	2570 mm
Front track width	1570 mm	1570 mm
Rear track width	1575 mm	1554 mm
Turning circle	9.9 m	9.9 m
Standard front tires	155/70 R19 84Q ET 43	155/70 R19 84Q ET 43
Standard rear tires	155/70 R19 84Q ET 43	175/60 R19 86Q ET 53
Front axle support	Without connection for fuel tank	Connection for fuel tank
Anti-roll bar, front	mechanical	mechanical
Rear anti-roll bar	no	no

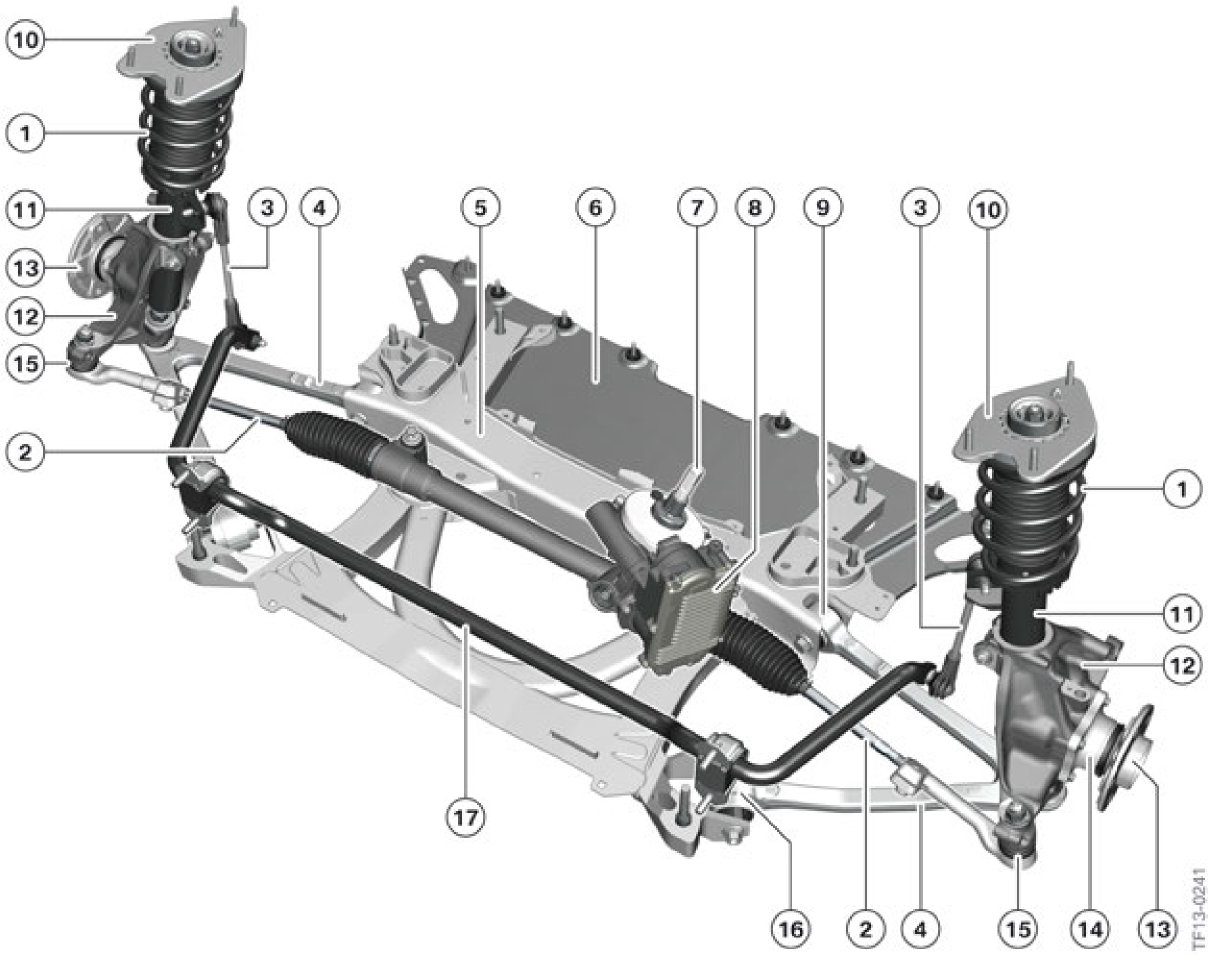
I01 Chassis and Suspension
1. Introduction

Designation	I01 without range extender	I01 with range extender
Front brake	Brake disc with internal ventilation 280 x 20	Brake disc with internal ventilation 280 x 20
Rear brakes	Brake disc without ventilation 280 x 8.6	Brake disc without ventilation 280 x 8.6
Parking brake, rear	Electromechanical parking brake	Electromechanical parking brake
Vehicle weight for ECE	1195 kg	1315 kg

Depending on the market, the vehicle weights may vary due to the various equipment ranges and prerequisites for approval.

2. Axles

2.1. Front axle



I01 Front axle

Index	Explanation
1	Coil spring
2	Track rod
3	Anti-roll bar link
4	Wishbone arm suspension
5	Front axle support
6	Stiffening plate
7	Steering box
8	Electronic Power Steering (EPS)
9	Wishbone arm suspension rubber mount for absorption of lateral forces
10	Support bearing
11	Spring strut

Index	Explanation
12	Swivel bearing
13	Wheel hub
14	Wheel bearing unit
15	Track rod end
16	Wishbone arm suspension rubber mount for absorption of tensile forces
17	Anti-roll bar

The single-joint spring-strut-type front axle used in the I01 offers a high degree of ride comfort due to its low unsprung masses.

The front axle support (5) is the core of the front axle and is bolted to the Drive module at several points. The stiffening plate (6) also connects the front axle to the Drive module in addition to the bolting points of the front axle support. This ensures the necessary rigidity of the front axle. The vehicle must not be driven without stiffening plate! The stiffening plate ensures transverse rigidity of the vehicle and increases, in combination with the front axle support, the rigidity of the front axle.

A conventional anti-roll bar (17) reduces the rolling movement of the body, particularly during cornering.

The swivel bearing (12) is screwed to the front axle support via the wishbone arm suspension (4) with a rubber mount for absorbing transverse forces (9) and a rubber mount for absorbing tensile forces (16).

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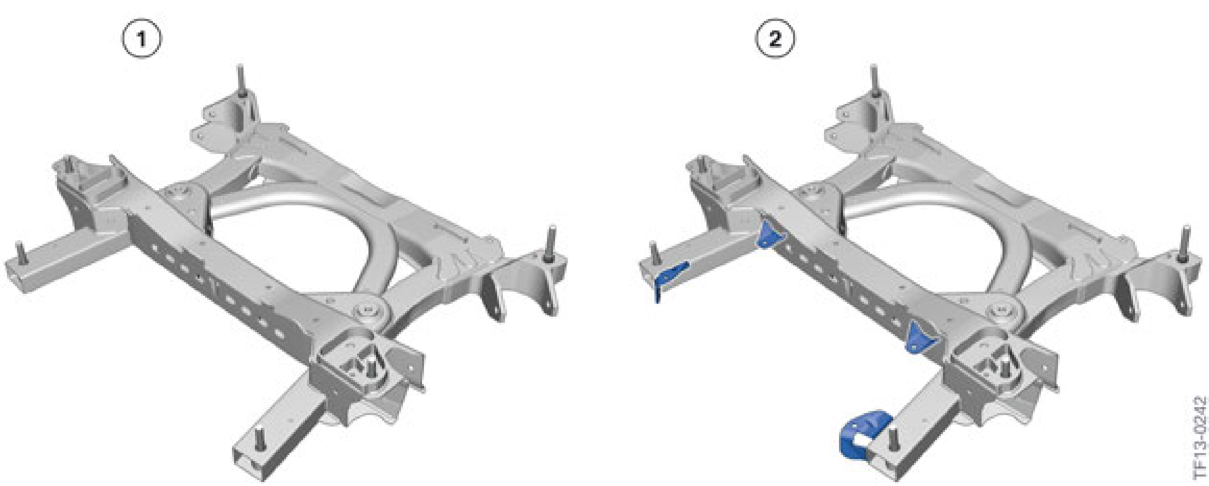
Note that it is **not** permitted to carry out a test drive with the stiffening plate disassembled as the front axle will not be sufficiently rigid.

2.1.1. Versions of the front axle support

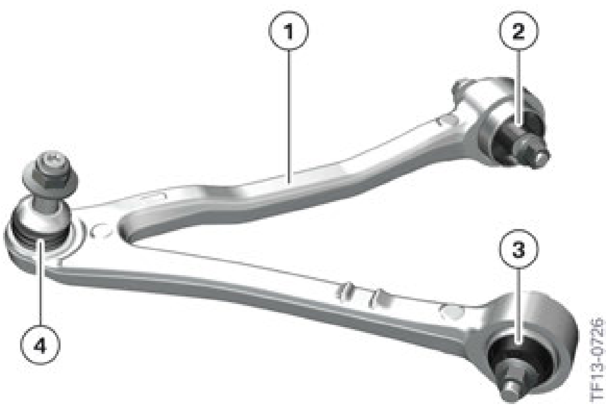


I01 Versions of the front axle support

Index	Explanation
1	Front axle support for vehicles without range extender
2	Front axle support for vehicles with range extender

There are two different versions of the front axle support. If the vehicle is equipped with a range extender, there will be a total of four connections at the front axle support (2) for mounting the fuel tank. These connections do not exist in the version without range extender (1). The front axle support is bolted to the Drive module via six screws which can be replaced individually in Service, providing the damage is limited to the front axle support. Damage which affects the structure of the Drive module in addition to the front axle support must be rectified by a qualified BMW i Service Center.

2.1.2. Wishbone arm suspension



I01 Wishbone arm suspension

Index	Explanation
1	Wishbone arm suspension
2	Wishbone arm suspension rubber mount for absorption of tensile forces
3	Wishbone arm suspension rubber mount for absorption of lateral forces
4	Wheel guide joint

The wheel guide joint (4) ensures a connection between the wishbone arm suspension (1) and the swivel bearing that is free of play. The two wishbone arm suspension rubber mounts (2, 3) connect the wishbone arm suspension to the front axle support and reduce sound waves and oscillations caused by rolling of the wheels.

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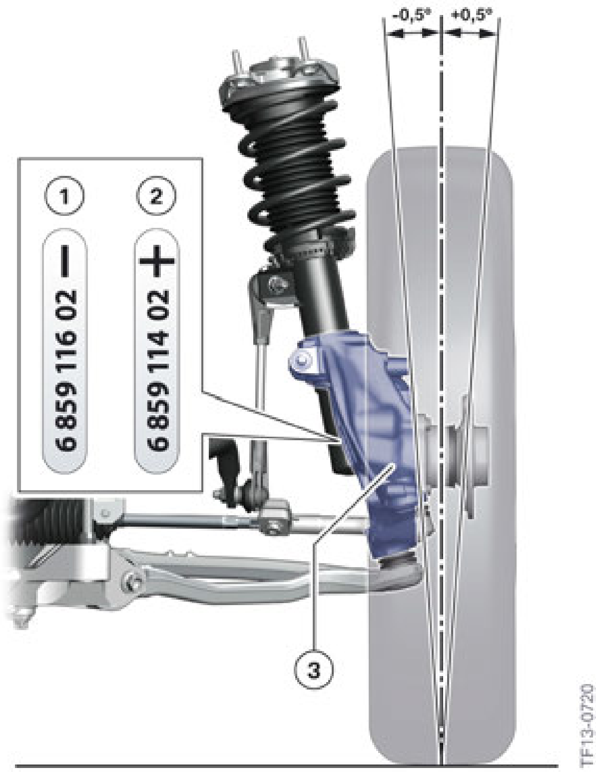
When exchanging the two wishbone arm suspension rubber mounts refer to the current repair instructions.

2.1.3. Swivel bearing



I01 Swivel bearing

Index	Explanation
1	Identification, swivel bearing camber adjustment, minus 30`
2	Identification, swivel bearing camber adjustment, plus 30`
3	Swivel bearing

The camber is defined by the wheel center plane and perpendicular to the roadway. The camber at the front axle cannot be adjusted. If the camber tolerances are exceeded, two different swivel bearing camber adjustments exist in Service for setting the camber (1, 2) correctly. The swivel bearing camber adjustments (1, 2) vary in terms of alignment of the shock absorber axis in relation to the wheel bearing bolt-on surface via which the camber of the vehicle is adjusted. This variation in this swivel bearing geometry allows the camber to be adjusted positively or negatively.

The table below provides an overview of the different swivel bearing versions.

Versions	Component identification at the vehicle	Correction value
Standard swivel bearing	without	without
Swivel bearing camber adjustment	+	Plus 30`
Swivel bearing camber adjustment	-	Minus 30`

In addition, the swivel bearing on the left-hand side of the vehicle is not the same as the as the swivel bearing on the right-hand side of the vehicle. As a result, three different versions and six different part numbers exist in total.

2.1.4. Single-joint spring-strut-type front axle

I01 Negative kingpin offset

Index	Explanation
A	Kingpin offset
1	Axis of movement
2	Wheel center axis

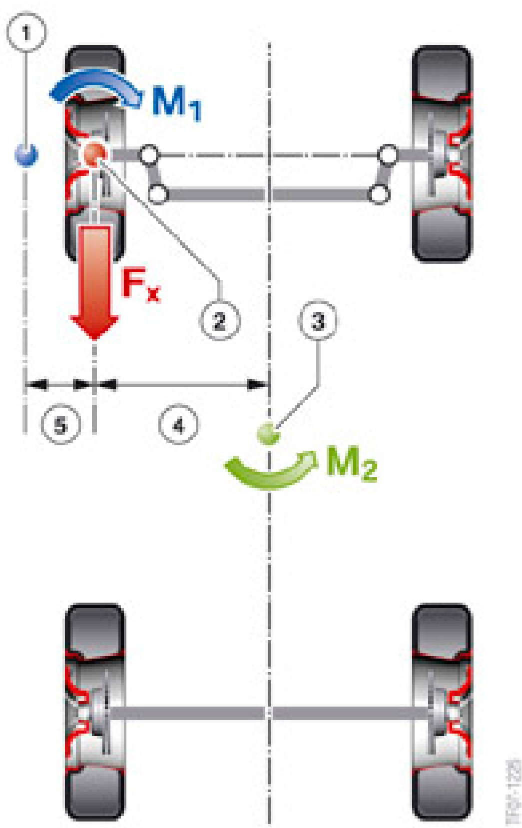
The kingpin offset (A) is the lever arm at which the frictional forces arising between the tire and roadway engage. It is measured between the center of the tire contact area at the wheel center axis (2) and the point at which the extended axis of movement (1) passes through the roadway.

In general, the kingpin offset (A) should be as small as possible to ensure that the influence of external forces on the steering is kept to a minimum. With the single-joint spring-strut-type front axle, the wheel guide joint of the wishbone arm suspension through which the axis of movement (1) passes largely influences the size of the kingpin offset (A). As the kingpin offset (A) should be as small as

possible, the wheel guide joint must be as far as possible to the outside. In addition to the axle concept and chassis adjustment, selecting rims with a suitable rim offset can also however achieve the required effect on the kingpin offset (A).

A two-joint spring strut front axle, as used in the F30 for example, offers more installation space, in contrast with the single-joint spring-strut-type front axle of the I01. The additional joint brings about a virtual axis of movement. This means that, when compared to the single-joint spring-strut-type front axle, the two joints can be located further towards the inside. The installation space this gains is favorable for the brake system.

Due to the following correlations, it was possible to use a single-joint spring-strut-type front axle with the I01. The rim offset of the wheel rims at the front axle of the I01 is 43 mm. By way of comparison, the rim offset of the wheel rims of a F22 228i is only 33 mm. This large rim offset shifts the tire tread surface further towards the center of the vehicle. This has the effect of also displacing the wheel center axis (2) towards the center of the vehicle. The kingpin offset (A) reduces accordingly. The necessary installation space for the brake system can also be ensured by using the 19" wheel rims in the base model and the 20" wheel rims which are available as optional equipment.



I01 Effect of kingpin offset with one-sided brake force

Index	Explanation
1	Point at which the axis of movement passes through the roadway (drawn superimposed on illustration)
2	Wheel contact point
3	Center of gravity of vehicle
4	Distance of wheel center plane from the vehicle longitudinal axis
5	Kingpin offset
F_x	One-sided application of brake force
M_1	Torque at the wheel
M_2	Torque at the vehicle

With the I01 however, a negative kingpin offset (5) has been chosen instead of a neutral kingpin offset (5). One of the reasons for this is the diagonal split braking system of the vehicle.

A positive kingpin offset has the effect of tilting the wheel with more effective traction further towards the outside if the traction in the wheels during braking is not the same. The vehicle pulls over to one side as a result.

With a negative kingpin offset it behaves in exactly the opposite manner. The wheel with the more effective traction produces a steering torque (M_1) which is directed inwards. When a brake circuit in the diagonal brake split system malfunctions, the wheel brake acts asymmetrically on the front axle (F_x). This causes a torque (M_2) build up around the center of gravity of the vehicle (3). This causes the vehicle to pull to the left. The torque at the wheel (M_1) produced by the negative kingpin offset (5) counteracts the torque at the vehicle (M_2). The two torques counteract one another thus reducing the tendency of the vehicle to pull to one side.

2.1.5. Notes for Service

The following table shows when wheel alignment at the front axle is necessary when replacing a component.

Replacing the components at the front axle	Wheel alignment required
Front axle support	YES
Electronic Power Steering (EPS)	YES
Wishbone arm suspension	YES
Track rod	YES
Swivel bearing	YES
Wheel bearing unit	NO
Spring strut	NO
Coil spring	NO
Support bearing	NO
Stiffening plate	NO

I01 Chassis and Suspension
2. Axles

The following table shows when wheel alignment at the front axle is necessary when a component is detached.

Undoing the screw connection at the front axle	Wheel alignment required
Front axle support to Drive module	NO
EPS to front axle support	YES
Wishbone arm suspension rubber mount for absorption of lateral forces	YES
Wishbone arm suspension rubber mount for absorption of tensile forces	YES
Track rod end to swivel bearing	NO
Wishbone arm suspension to swivel bearing	NO
Track rod to EPS	NO
Track rod end to track rod	YES
Track rod end to swivel bearing	NO
Spring strut to swivel bearing	NO
Support bearing to Drive module	NO
Steering shaft to steering gear	NO
Steering column to steering shaft	NO

The purpose of the following table is to provide an overview of the adjustment values of the standard version of the I01 chassis and suspension at the front axle.

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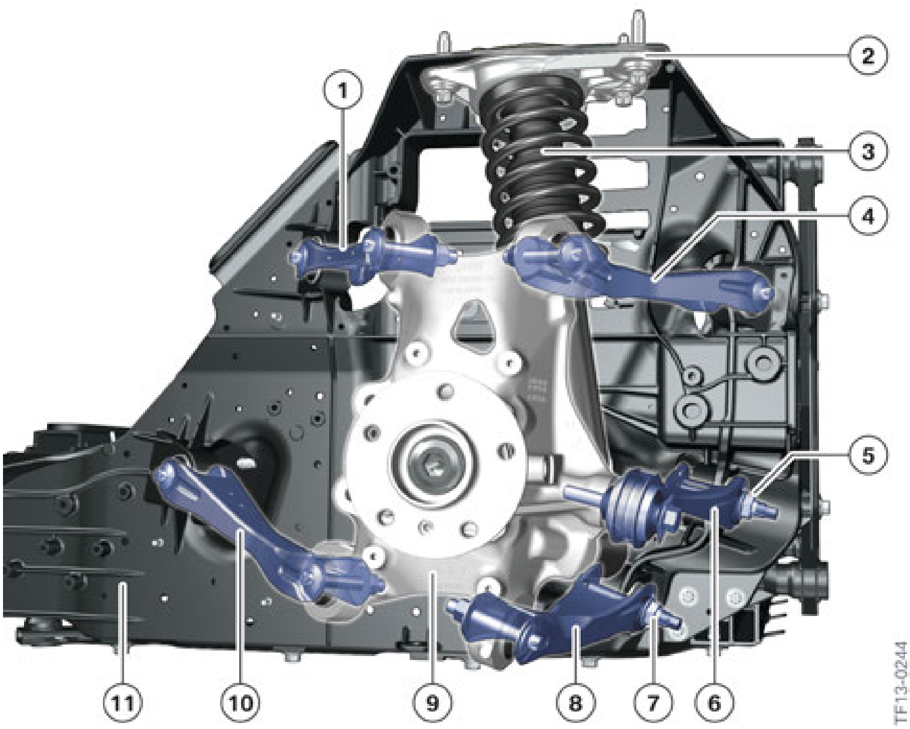
For the adjustment values in Service, refer to the current data records of the **BMW Kinematics Diagnosis System.**

Front axle adjustment values	I01 Standard chassis and suspension
Castor angle Tolerance Difference between left and right	4.5° +/- 30\` +/- 30\`
Camber Tolerance Difference between left and right	- 20\` +/- 25\` +/- 30\`
Toe-in Tolerance	7\` +/- 2\`
Total toe-in Tolerance	14\` +/- 12\`

Front axle adjustment values	I01 Standard chassis and suspension
Kingpin offset	- 1.99 mm
Toe difference angle at 20° Tolerance	2° 15` +/- 30`
Spread angle Tolerance	14° +/- 30`

2.2. Rear axle



I01 Rear axle suspension arm

Index	Explanation
1	Control arm
2	Support bearing
3	Spring strut
4	Wishbone
5	Eccentric bolt, track control arm
6	Camber link
7	Eccentric bolt, camber control arm

Index	Explanation
8	Camber link
9	Wheel carrier
10	Trailing arm
11	Rear axle module

The I01 features the rear axle used for the first time in the E87 (E90 in the US), the HA5. This is an independent multi-link suspension with 5 different suspension arms. The name HA5 is however not derived from the different suspension arms, and instead stands for the ongoing development code at BMW.

The wheel carrier (9) is guided by five rubber-mounted suspension arms. The positioning of the wheel carrier (9) can be modified via the track control arm (6) and camber control arm (8). The Service employee can adjust the camber and tracking with the assistance of the eccentric bolts (5, 7).

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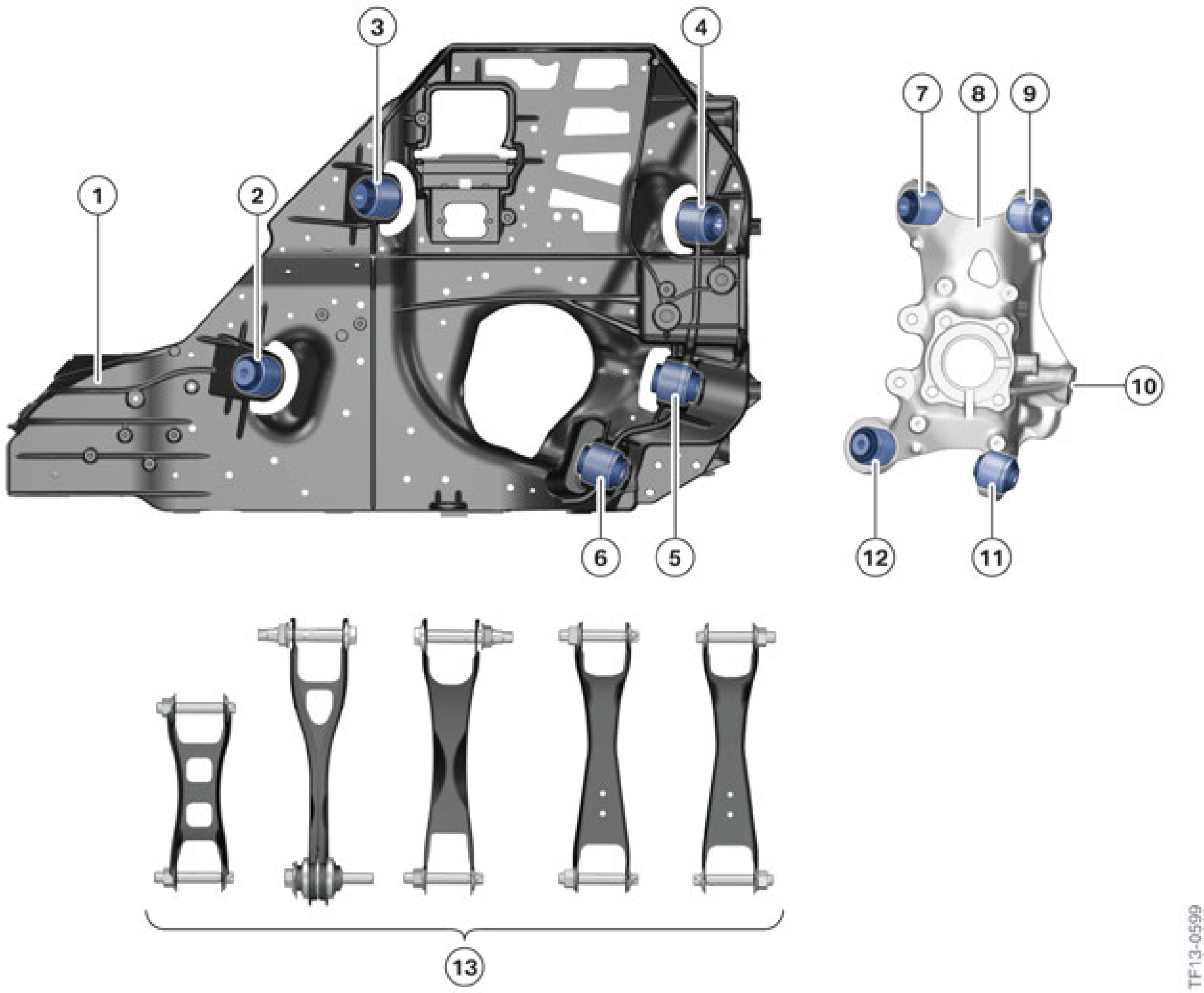
During wheel alignment, the nuts of the eccentric bolts must be replaced once they have been undone. When tightening the nuts, follow the specifications in the repair instructions.

2. Axles



I01 Overview of rubber mounts at the rear axle

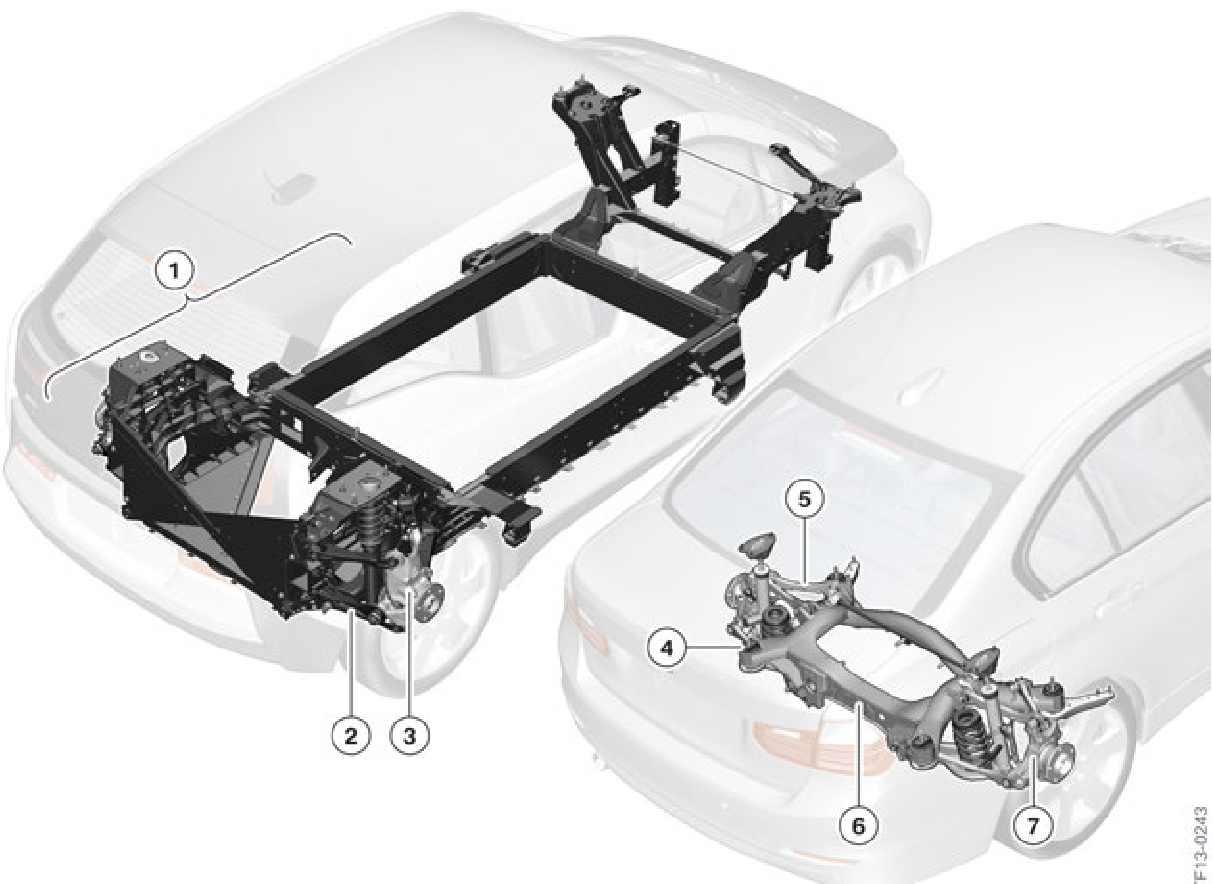
Index	Explanation
1	Rear axle module
2	Rubber mount, trailing arm at rear axle module
3	Rubber mount, control arm at rear axle module
4	Rubber mount, wishbone at rear axle module
5	Rubber mount, track control arm at rear axle module
6	Rubber mount, camber control arm at rear axle module
7	Rubber mount, control arm at wheel carrier
8	Wheel carrier
9	Rubber mount, wishbone at wheel carrier

Index	Explanation
10	Mounting of track control arm with rubber mount to wheel carrier
11	Rubber mount, camber control arm at wheel carrier
12	Rubber mount, trailing arm at wheel carrier
13	Five suspension arms of rear axle

The rubber mounts of the suspension arm (13) are permanently pressed into the rear axle module (1) and the wheel carrier (8). As can be seen in the above graphic however, the track control arm is equipped with a rubber mount which is pressed into the suspension arm on the wheel carrier side.

2.2.1. Five-link rear suspension

The purpose of the following illustration is to show the differences between a HA5 rear axle in the F30 and the HA5 rear axle in the I01.



I01 Rear axle concept compared to F30

2. Axles

Index	Explanation
1	Rear axle module I01
2	Rubber mounted suspension arm I01
3	Wheel carrier I01
4	Rubber mount, axle support F30
5	Rubber mounted suspension arm F30
6	Axle support F30
7	Wheel carrier F30

The five-link rear axle HA5 of the F30 consists of an axle support (6), the wheel carrier (7) and the five suspension arms. The axle support is bolted onto the body via four rubber mounts (4). The wheel carrier is connected to the axle support (6) via different suspension arms (5) on rubber bearings. This design ensures double damping between the body and the road.

The five-link rear axle HA5 of the I01 consists of the rear axle module (1), the wheel carrier (3) and the five suspension arms. It was possible to further reduce the vehicle weight by omitting an anti-roll bar on the rear axle.

Reasons for omission of an anti-roll bar:

- The ideal location of the high-voltage battery unit
- A high torsional rigidity of the rear axle module
- A harder suspension and damping control.

A low center of gravity due to the position of the high-voltage battery unit, high torsional rigidity of the rear axle module in conjunction with a harder suspension and damping control ensure low vehicle roll movements.

The difference in weight between the two versions – with and without range extender – is 120 kg. This difference in weight is compensated for by varying the suspension and damping control. It has been possible to ensure that the drivability of the version with range extender remains on a par with the version without range extender.

The wheel carrier of the I01 is screwed to the rear axle module directly via the five different suspension arms (2) with rubber bearings. It has therefore been possible to omit an axle support. The reduced vehicle weight in turn favorably affects the range. The body is damped once in the direction of the road. As an axle support with rubber mount has been omitted, the rubber mounts of the suspension arm of the I01 must meet more stringent demands.

The sound waves produced by rolling and oscillations caused by unevenness in the road surface should not be transmitted to the Drive module. The Drive module is therefore decoupled via the various rubber mounts of the suspension arms at the rear axle.

I01 Chassis and Suspension
2. Axles

Requirements to be met by the rubber mount:

- Guarantee play
- Guarantee zero wear
- Dampen oscillations
- Dampen sound waves.

The following conflicting objectives therefore arise: The elasticity of the rubber mounts must be as high as possible in order to dampen the oscillations and sound waves. The elasticity must be as low as possible to guarantee the a low amount of play and therefore that the specified wheel alignment position will not change significantly.

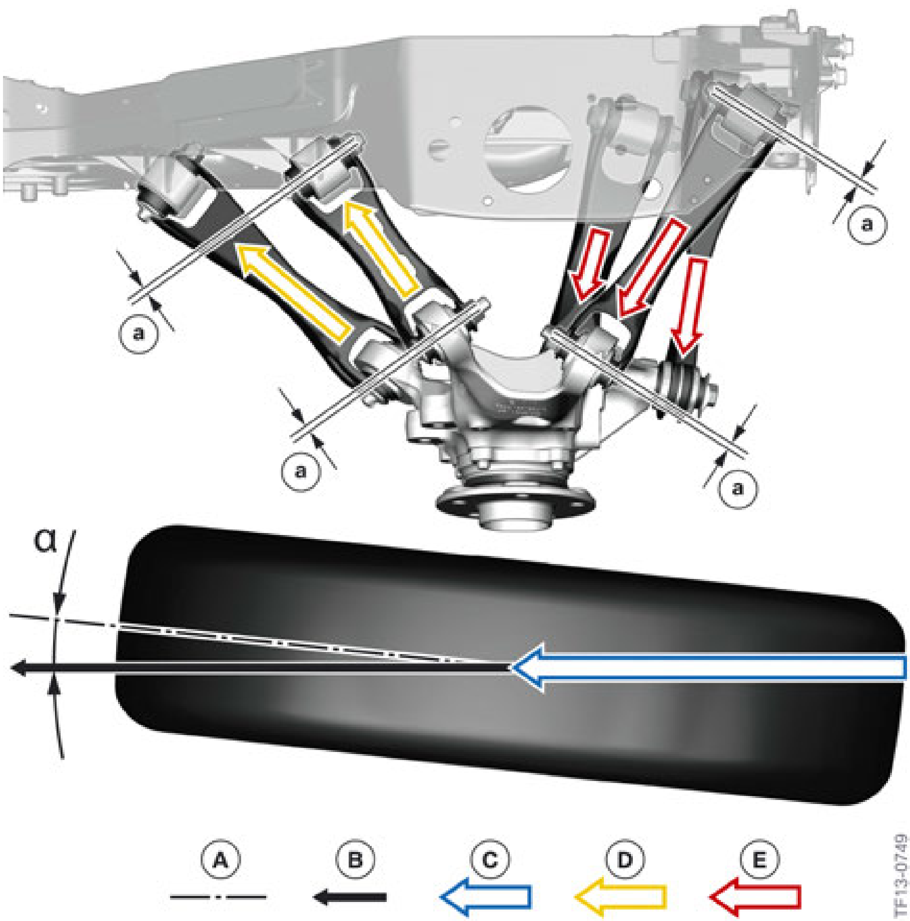
Measures for resolving conflict of objectives:

- The sound waves and oscillations are further reduced due to the installation of comfort-optimized bearings with a high elasticity
- Design measures involving the precise definition of the suspension arm positions bring about a high directional stability of the rear axle wheels.

I01 Chassis and Suspension

2. Axles

Design measures



I01 Elasticity of the rear axle bearing

Index	Explanation
A	Wheel center plane
B	Direction of travel
C	Driving power
D	Compressive forces
E	Tensile forces
α	Steering angle (drawn superimposed on illustration)
a	Elasticity of rubber mount

To achieve the necessary ride comfort, the elasticity of the rubber mounts used for mounting on axle constructions has been harmonised with the vehicle. Undesirable steering wheel movements occur when the vehicle is in motion in various driving situations due to the flexible rubber mounts between the rear axle module and wheel carrier. Steering angles (α) occur if forces act on the wheel and it moves out of the direction of travel by a steering angle (α) in the direction of the toe-in or toe-out.

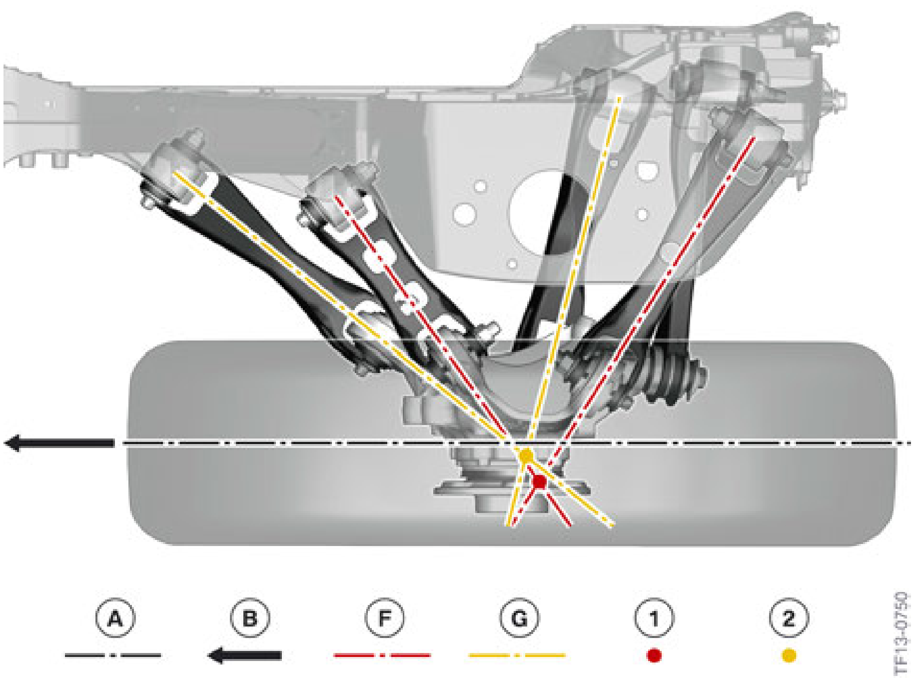
I01 Chassis and Suspension

2. Axles

The following forces can occur in this case:

- Driving power
- Brake forces
- Lateral forces
- Vertical forces.

The above graphic shows flexible steering errors that occur during acceleration. As the driving power (C) that engages the driven wheel of the rear axle, tensile forces (E) act on the three suspension arms at the rear of the vehicle. Compressed forces (D) on the other hand are applied to the two front suspension arms. Due to the elasticity of the rubber mounts (a) at the various suspension arms, movement occurs within the rubber mount. This brings about a steering movement of the driven wheel. The vehicle deviates from its course as a consequence.



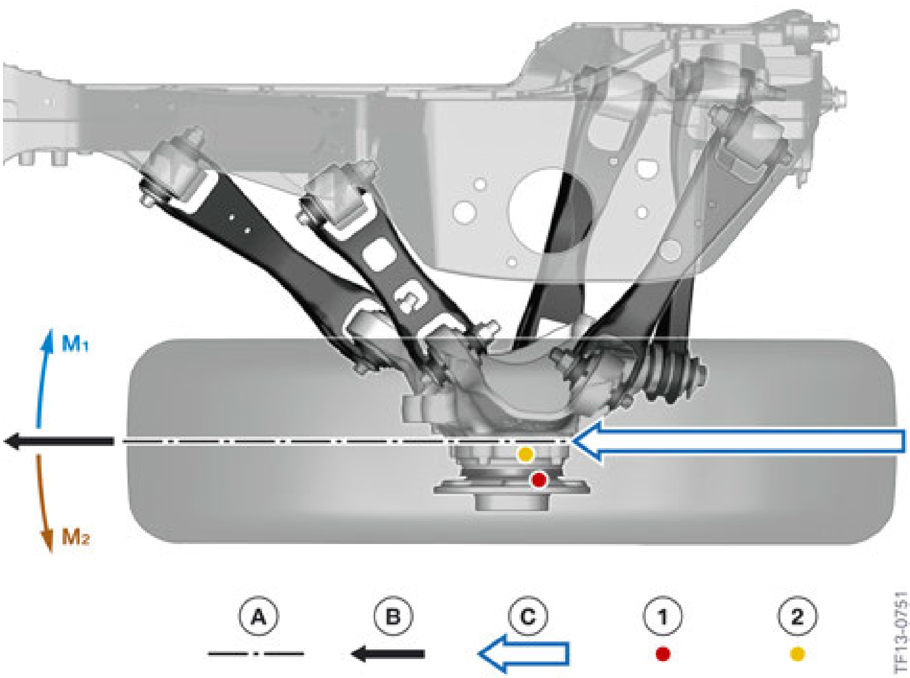
I01 Intersection points of suspension arm center lines

Index	Explanation
A	Wheel center plane
B	Direction of travel
F	Suspension arm center line, upper suspension arm pair
G	Suspension arm center line. lower suspension arm pair
1	Intersection of upper suspension arm pair
2	Intersection of lower suspension arm pair

In the top view a triangle is visible above the two top suspension arms. The two lower suspension arms produce an additional triangle. The rear suspension arm (shown in the figure without wishbone center line) represents the track control arm. The two suspension arm center lines (F, G) shown in red and

orange in the graphic form one intersection at their respective ends (1, 2). The suspension arm center line of the top suspension arm pair (F) ends at the intersection with the top suspension arm pair (1). The suspension arm center line of the bottom suspension arm pair (G) ends at the intersection of the bottom suspension arm pair (2).

The intersections of the top and bottom suspension arm pairs (1, 2) lie outside the wheel center plane (A). The constructional position of the two intersections of the bottom and top suspension arm pairs (1, 2) results in the positive effect on drivability shown below.



I01 Balancing of steering torques at the rear axle

Index	Explanation
A	Wheel center plane
B	Direction of travel
C	Driving power
1	Intersection of upper suspension arm pair
2	Intersection of lower suspension arm pair
M_1	Inwards steering torque
M_2	Outwards steering torque

The purpose of the above graphic is now to summarize the effects previously demonstrated. Its purpose is also to illustrate which constructional solutions can assist in resolving the conflict of objectives between comfort and rigidity.

As already described at the outset, the driving power (C) produces an inwards steering torque (M_1). In order to ensure the drivability of the vehicle remains stable, a steering torque must act in the opposing direction during the same period.

I01 Chassis and Suspension

2. Axles

Due to the constructional position of the two intersection points of the top and bottom suspension arm pair (1, 2) outside the wheel center plane (A), an outwards steering torque (M_2) occurs, e.g. when influenced by driving power (C), which counteracts the inwards steering torque (M_1) that is produced. The wheel remains in its predefined position. The drivability remains stable.

2.2.2. Notes for Service

The following table shows when wheel alignment at the rear axle is necessary when replacing a component.

Replacing the component at the rear axle	Wheel alignment required
Rear axle module	YES
Rubber mount, track control arm at rear axle module	YES
Rubber mount, camber control arm at rear axle module	YES
Rubber mount, trailing arm at rear axle module	NO
Rubber mount, wishbone at rear axle module	NO
Rubber mount, control arm at rear axle module	NO
Camber link	YES
Camber link	YES
Trailing arm	NO
Control arm	YES
Wishbone	YES
Wheel carrier	YES
Wheel bearing unit	NO
Spring strut	YES
Support bearing	YES

The following table shows when wheel alignment at the rear axle is necessary when detaching a component.

Undoing the screw connection at the rear axle	Wheel alignment required
Drive module to body	NO
Wishbone to rear axle module	NO
Trailing arm to rear axle module	NO
Control arm to rear axle module	NO
Camber control arm to rear axle module	YES
Track control arm to rear axle module	YES
Wishbone to wheel carrier	NO
Trailing arm to wheel carrier	NO
Control arm to hub carrier	NO

I01 Chassis and Suspension

2. Axles

Undoing the screw connection at the rear axle	Wheel alignment required
Camber link to wheel carrier	YES
Camber link to wheel carrier	YES
Spring strut to wheel carrier	NO

The purpose of the following table is to provide an overview of the adjustment values of the standard version of the I01 chassis and suspension at the rear axle.

⚠

For the adjustment values in Service, refer to the current data records of the BMW Kinematics Diagnosis System.

Rear axle adjustment values	I01 Standard chassis and suspension
Camber Tolerance Difference between left and right	- 1° 40\` +/- 5\` +/- 30\`
Toe-in Tolerance	9\` +/- 2\`
Total toe-in Tolerance	18\` +/- 12\`
Driving axis angle Tolerance	0\` +/- 12\`

I01 Chassis and Suspension

3. Wheels

3.1. Wheels

Forged aluminium rims are used with the basic and optional equipment.

Four different wheel sets in total are available. The vehicle can be equipped with 19" or 20" wheel rims, depending on the customer request.

I01 Overview of aluminium rims

Index	Explanation
1	Basic equipment, star spoke 19" (427)
2	Optional equipment, turbine styling 19" (428)
3	Optional equipment, turbine styling 19" (429)
4	Optional equipment, double spoke 20" (430)

3.1.1. Wheel sizes

The following table provides an overview of the various wheel sizes with reference to the two versions with and without range extender.

3. Wheels

Tires	I01 without range extender	Rim size	I01 with range extender	Rim size
Basic version, summer tire, front	155/70 R19 84 Q	5J x 19 ET 43	155/70 R19 84 Q	5J x 19 ET 43
Basic version, summer tire, rear	155/70 R19 84 Q	5J x 19 ET 43	175/60 R19 86 Q	5.5J x 19 rim offset 53
Basic version, winter tire, front	155/70 R19 84 Q	5J x 19 ET 43	155/70 R19 84 Q	5J x 19 ET 43
Basic version, winter tire, rear	155/70 R19 84 Q	5J x 19 ET 43	155/70 R19 84 Q	5J x 19 ET 43
OE summer tire, front	155/60 R20 80 Q	5J x 20 rim offset 43	155/60 R20 80 Q	5J x 20 rim offset 43
OE summer tire, rear	175/55 R20 85 Q	5.5J x 20 rim offset 53	175/55 R20 85 Q	5.5J x 20 rim offset 53

The front and rear axles of the (standard) I01 without range extender are equipped with the same tires and rim size (mixed tires are available as an option). If the vehicle is equipped with a range extender, mixed tires are standard in order to satisfy the higher demands in relation to driving dynamics due to the increased rear axle loads. By using 175/60 R19 tires, it has been possible to ensure that the driving dynamics of the I01 with range extender remain on a par with the driving dynamics of the I01 without range extender. This means that the drivability of the I01 is the same for each customer, irrespective of which vehicle version they drive.

The expression driving dynamics is a very general term which can be broken down into various sub-areas. The following sub-areas must therefore be considered in order to compare the two vehicle versions.

Subareas of driving dynamics:

- Longitudinal dynamics
  Describes the vehicle behavior during acceleration and deceleration operations. The traction, braking deceleration and driving resistance, for example, are analyzed.
- Transverse dynamics
  Describes the vehicle behavior during cornering. The steering behavior, directional stability and tilting tendency for example, are analyzed.
- Vertical dynamics
  Describes the vehicle drivability over bumps. The effects on the comfort of the occupants and payload for example, are analyzed.

If the I01 with range extender is converted for winter tires, R19 tires are also used at the rear axle 155/70.

Reasons for using the low tire width:

- It was only possible to ensure sufficient freedom of movement when using snow chains with tire size 155/70 R19
- Improved traction and braking deceleration on smooth or wet roads is achieved using 155/70 R19 tires.

Winter tires are not available for the optional equipment 20" wheel rim, also due to freedom of movement of the snow chains.

The vehicle is equipped in all dimensions with rolling resistance optimized tires without emergency running properties.

There is no spare wheel recess in the I01 therefore compact spare wheel for use in the event of a puncture is not provided. All US market vehicles come with a Mobility Kit included as standard equipment.

Overall the omission of the spare wheel and use of tires without emergency running properties provides benefits in terms of reducing the vehicle weight and thus increasing the range.

3.2. Tire pressures

3.2.1. Physical principles

Optimum adjustment of tire pressure is necessary for various reasons.

Reasons:

- Best possible driving dynamics
- Maximum utilisation of tire service life
- Increase in maximum ranges
- Secure function of different puncture detection systems.

For this, the physical principles should be observed in combination with pressure and temperature. The following rule of thumb applies in this case: A temperature change of 10 °C produces an increase in tire pressure of roughly 0.1 bar.

3.2.2. Warm tire pressure

⚠

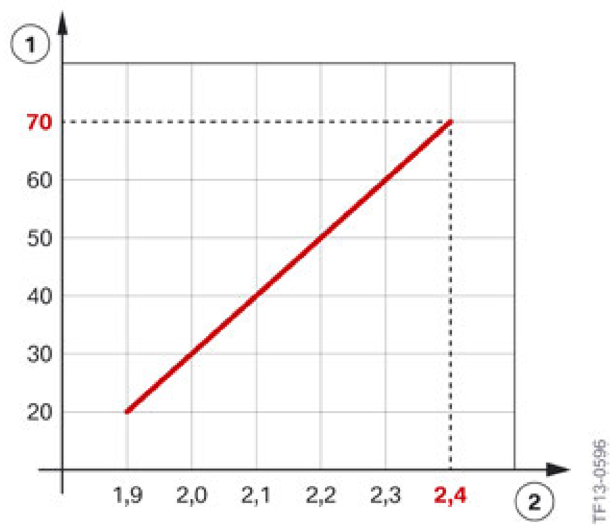
During longer journeys at higher driving speeds the tire warms up due to the friction with the road surface and tire creep. The temperature of the tire increases as a result and this is accompanied by an increase in tire pressure. If there is a significant difference between ambient temperature and tire air temperature this is always referred to as warm tire pressure. Avoid changing the tire pressures when the tire is warm.

3.2.3. Cold tire pressure

⚠

If the tire air temperature is the same as the current ambient temperature, this is referred to as cold tire pressure. The tire pressures should only be changed with cold tire pressure.

The tire pressures specified by the manufacturer apply for summer and winter operation, irrespective of the temperature. However, it must be observed that due to the seasonal temperature differences, the tire pressures should be frequently checked. The following figure shows the tire pressure curve as a function of the temperatures of the air in the tire.



I01 Tire pressure and temperature

Index	Explanation
1	Temperature of air in the tire in °C
2	Pressure in bar

Observe the following when correcting the tire pressures:

- Only change the tire pressures with cold pressure
- Following each change in tire pressure, it is necessary to initialize the puncture detection systems.

The purpose of the following example is to illustrate the problems arising from the correlations between temperature and pressure.

The temperature of the air in the tire when filled at warm tire pressure was around 70 °C (1). The corrected tire pressure is now around 2.4 bar (2). Initialization of the new tire pressures has been completed successfully. Following a longer standstill period the tire cools down to the ambient temperature of 20 °C (1). This results in a temperature difference of 50 °C. Based on the tire pressure this results in a new value of 2.4 bar – 0.5 bar = 1.9 bar (2).

If the vehicle is equipped with a tire pressure monitoring system TPMS, different warning threshold values apply.

Warning threshold values:

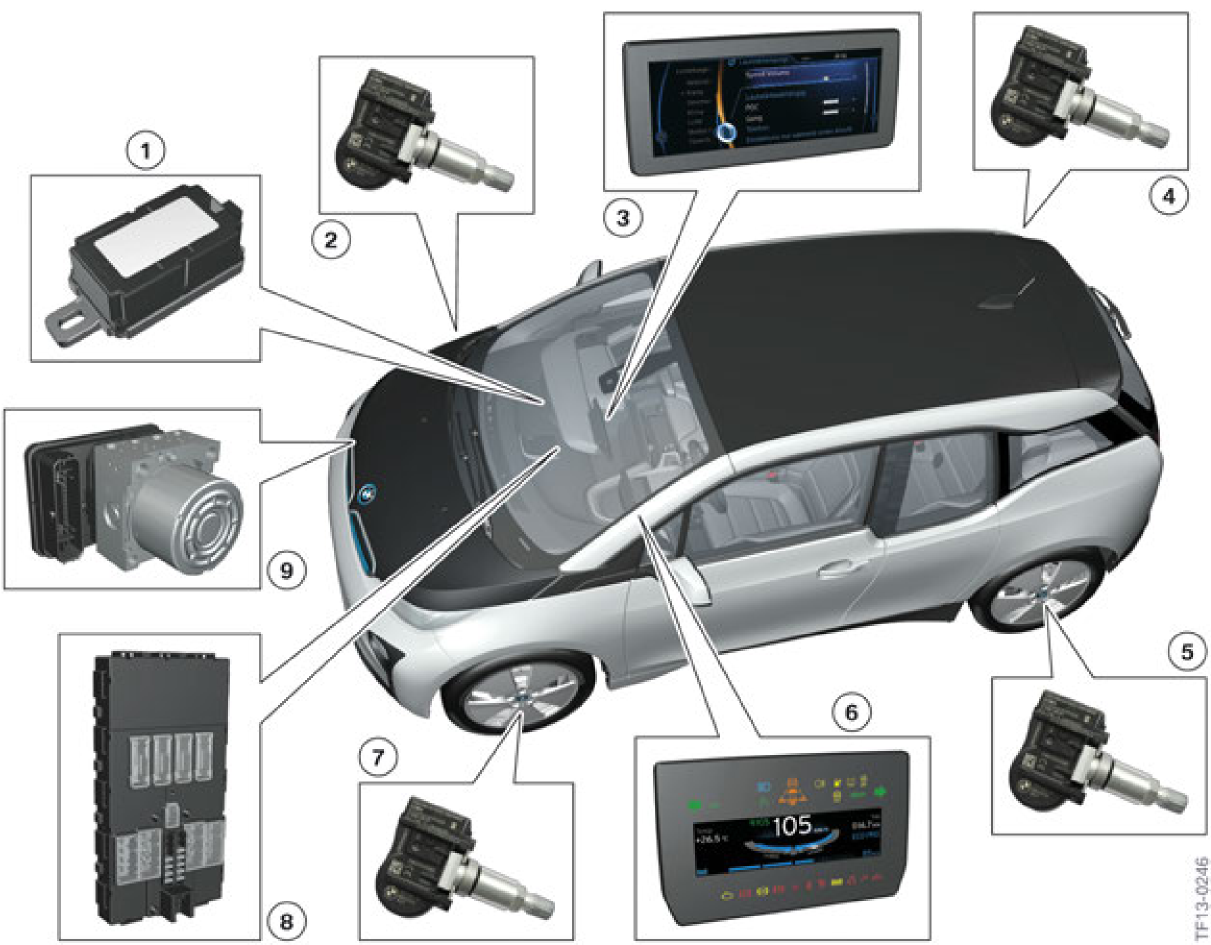
- If the tire pressure deviates by more than 20 % from the initialized nominal pressure
- If the warning threshold value of 1.6 bar is undercut.

As a consequence, a TPMS warning message is output if the deviation from the initialized nominal pressure is greater than 20 %.

The correct tire pressures are stated on the driver's side in the rear door.

If the tire is insufficiently filled, its rolling resistance will be higher which therefore contributes towards reducing the range of the I01.

3.3. Tire Pressure Monitoring System (TPMS)



I01 Overview of tire pressure monitoring system (TPMS)

3. Wheels

Index	Explanation
1	Remote control receiver (FBD)
2	Tire pressure sensor, front right
3	Central information display (CID)
4	Tire pressure sensor, rear right
5	Tire pressure sensor, rear left
6	Instrument panel (KOMBI)
7	Tire pressure sensor, front left
8	Body Domain Controller (BDC)
9	Dynamic Stability Control (DSC)

⚠

The Tire Pressure Monitoring System (TPMS) may also be referred to as RDC (Tire Pressure Control) in ISTA repair instructions and diagnostic material. TPMS is the term used for the US market version of RDC (Tire Pressure Control).

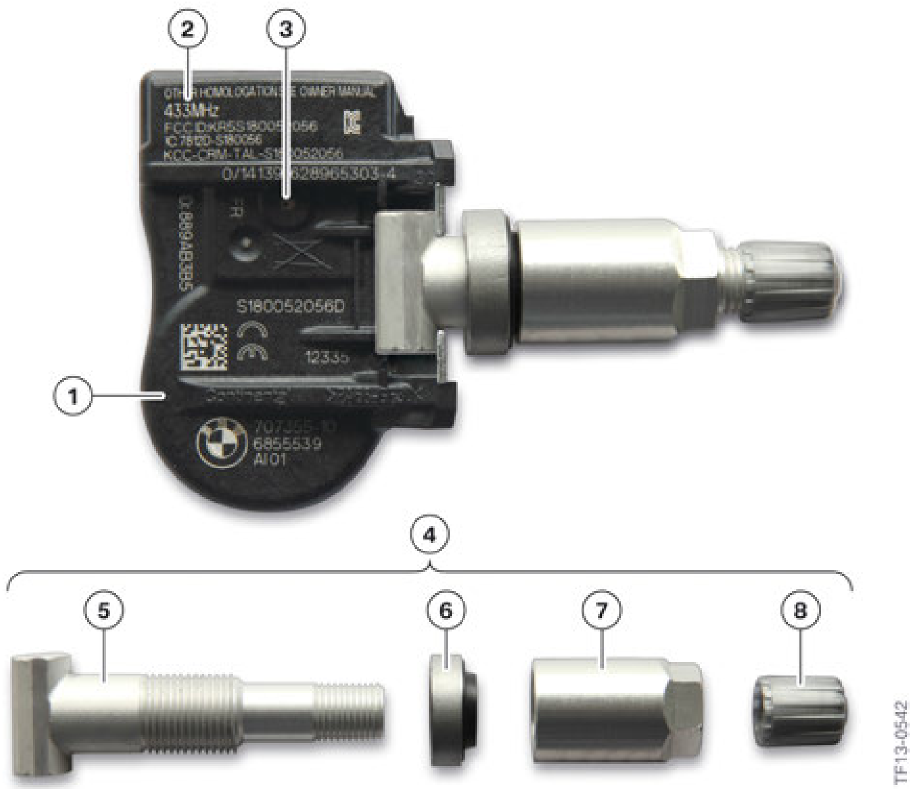
Tire pressure monitoring is a system for monitoring the actual tire pressure of all four wheels. The latest version of TPMS is used in the I01. It is integrated into the DSC control unit (9). This means that a separate TPMS control unit is not required.

The tire pressures and temperatures of the air in the tires are calculated by the tire pressure sensor (2, 4, 5, 7) at all four wheels and forwarded via radio signals. The radio signals from the tire pressure sensor are received by the remote control receiver (FBD) (1) and sent to the DSC control unit via FlexRay Bus signal the Body Domain Controller (BDC) (8). The evaluation function of the tire pressures takes place in the DSC control unit. The tire pressures can be displayed via the Central Information Display (CID). Warnings due to insufficient tire pressure are output via the CID or KOMBI (6).

I01 Chassis and Suspension

3. Wheels

3.3.1. Tire pressure sensor



I01 Tire pressure sensor with repair kit

Index	Explanation
1	Tire pressure sensor
2	Indication of transmission frequency
3	Pressure sensor
4	Repair kit
5	Valve unit
6	Sealing ring
7	Union nut
8	Valve cap

The tire pressure sensor consist of a pressure and temperature sensor, the radio transmitter, a timer, a battery, the acceleration sensor and the valve unit (5) with sealing ring (6), union nut (7) and valve cap (8). The tire pressure sensors send messages at defined intervals via radio signals to the remote control receiver (FBD). One message contains several data logs with information on the identification number (ID) of the tire pressure sensor, the current tire pressure, the temperature of the air in the tire and the battery status. As the ID numbers are different, the system can differentiate between the various tire pressure sensors.

I01 Chassis and Suspension
3. Wheels

The tire pressure sensor are located inside the tire. The battery status of the tire pressure sensor should therefore be determined with the assistance of the diagnosis system ISTA before each tire change. If it is likely that the service life of the tire will exceed the service life of the battery, the tire pressure sensor must also be replaced.

The tire pressure sensor used by BMW up till now cannot be used in the I01. The I01 features a new version of the tire pressure sensor. Therefore when replacing the tire pressure sensor on an I01, make sure that the correct version of the tire pressure sensor is installed.

If the valve unit is leaking, a repair kit (4) is available in Service. This eliminates the high costs involved in replacing the complete tire pressure sensor.

Before fitting the tire, check that the battery capacity of the tire pressure sensor is sufficient.

The TPMS will malfunction if the incorrect version of the tire pressure sensor is installed.

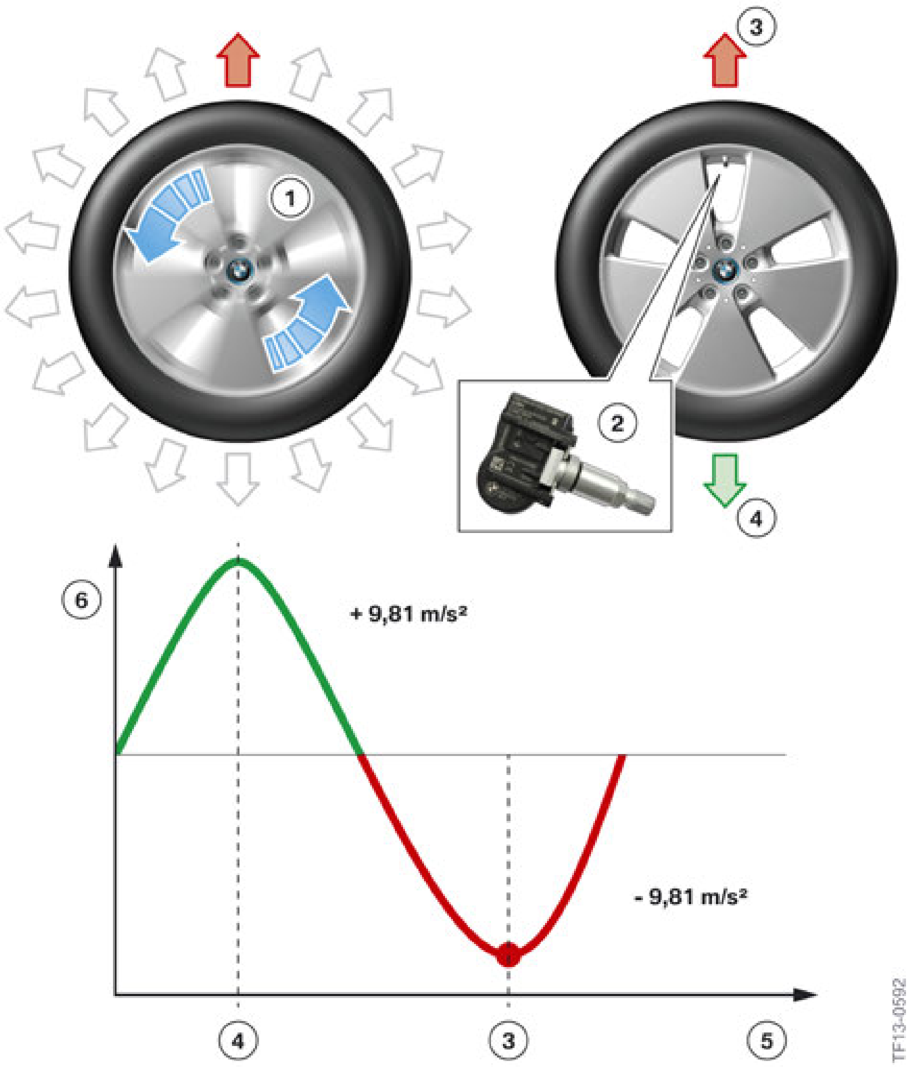
Note for Service

The service life of the batteries of the tire pressure sensor is roughly 10 years or 300,000 km. The current value of the service life counter, stated in years and months, can be read out with the help of the diagnosis system.

When removing/installing the tire pressure sensor, the following points must be observed:

- When fitting the tire, make sure the sensor is in the correct position as specified in the repair instructions.
- Do not use high pressure cleaners to clean the wheel rim with integrated tire pressure sensor when the tire has been removed.
- Replace the tire pressure sensor if tire sealant has been used.
- Clean the valve and valve seat thoroughly before installing the tire pressure sensor.
- Do not use solvents or detergents on the tire pressure sensor.
- Do not blow out the tire pressure sensor with compressed air.
- To clean the tire pressure sensor, simply wipe down with a clean cloth.

3.3.2. Rotation detection of tire pressure sensor



I01 Rotation detection of tire pressure sensor

Index	Explanation
1	Rotating wheel
2	12 o'clock position of tire pressure sensor
3	Force resulting from acceleration in opposition to gravitational acceleration
4	Force resulting from acceleration in the same direction as the gravitational acceleration
5	Wheel rotation in degrees
6	Force resulting from acceleration

3. Wheels

If a body is set in rotational motion (rotation is movement of a body around its own axis), forces arise due to the inertia. The axis of rotation, from where the acceleration and therefore the resulting force acts in all directions, lies at the center of the body. Based on this principle, the tire pressure sensor can determine whether the wheel is stationary or turning (1). The tire pressure sensor can be in the following modes.

Modes of tire pressure sensor:

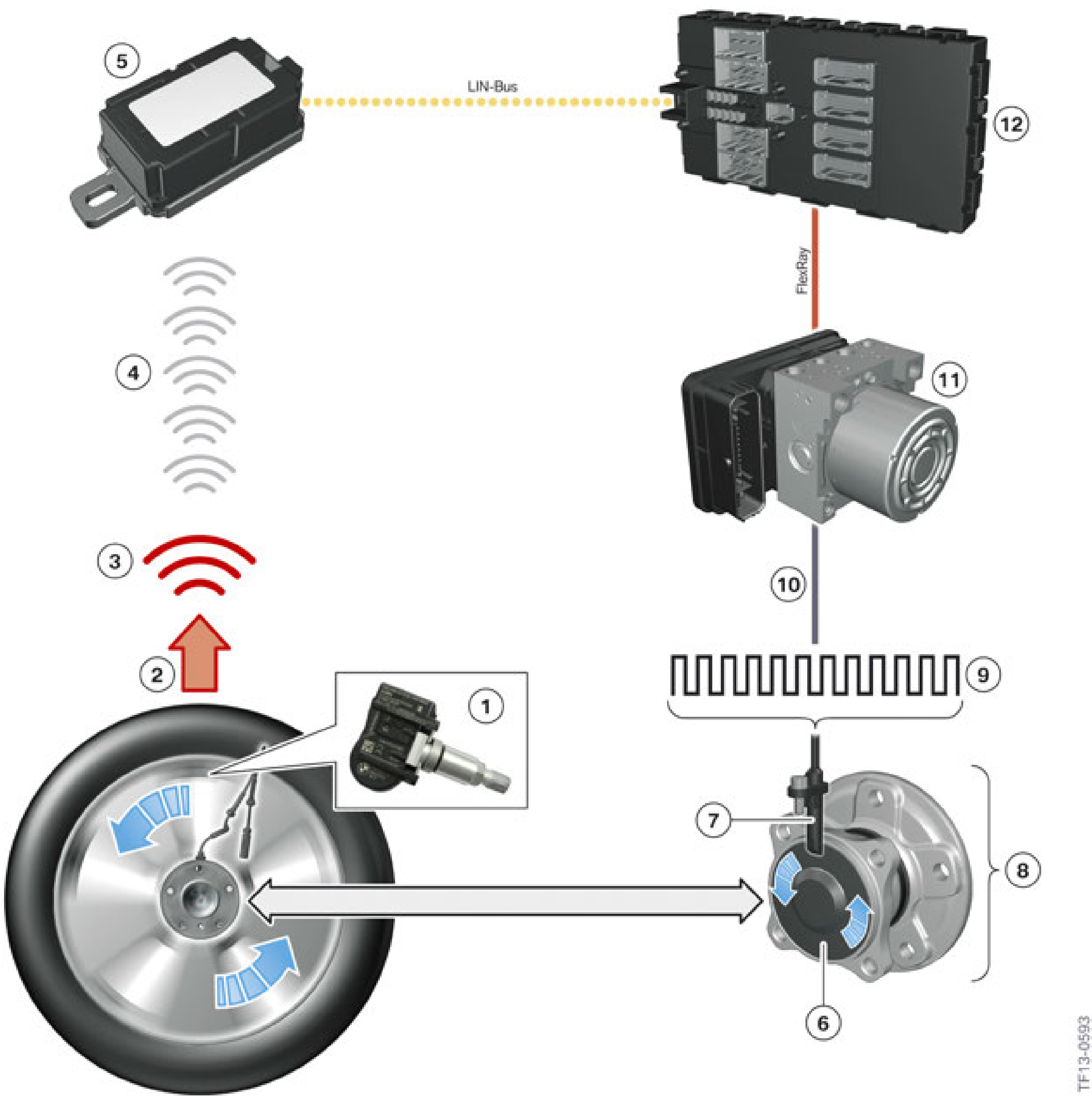
- Sleep mode
- Standby mode
- Teach-in mode.

An acceleration sensor is incorporated into each tire pressure sensor. If the acceleration sensor detects a stationary wheel, the tire pressure sensor switches to sleep mode. Messages are not sent to the remote control receiver (FBD) in sleep mode. This increases the service life of the batteries.

As soon as the vehicle starts moving, forces act on the tire pressure sensor. This force increases as the driving speed increases. If a speed of roughly 30 km/h is exceeded, the force is high enough to be captured by the acceleration sensor of the tire pressure sensor. The tire pressure sensors change to standby or teach-in mode and start transmitting at a defined interval.

The 12 o'clock position of the tire pressure sensor (2) can be determined in addition to the wheel rotation. An alternating force acts on the tire pressure sensor at the turning wheel. In the bottom valve position, the rotational movement of the wheel accelerates the tire pressure sensor towards the geocenter. The gravitational acceleration acts with 9.81 m/s² in the same direction which increases the force (4) acting on the tire pressure sensor. In the top valve position, the tire pressure sensor are accelerated away from the geocenter. The gravitational acceleration acts with 9.81 m/s² in the opposite direction, which reduces the force (3) acting on the tire pressure sensor. This effect means that the acceleration sensor in the tire pressure sensor can capture the force that is directed upwards (3). If the tire pressure sensor are in teach-in mode, the precise 12 o'clock position of the tire pressure sensor (2) is required.

3.3.3. Wheel assignment of tire pressure sensor



I01 Operating principle of wheel assignment

Index	Explanation
1	12 o'clock position of tire pressure sensor
2	Force resulting from acceleration in opposition to gravitational acceleration
3	Message
4	Transmission path
5	Remote control receiver (FBD)
6	Multi-pole sensor gear for ABS sensor

3. Wheels

Index	Explanation
7	Wheel speed sensor
8	Wheel bearing unit
9	Wheel speed signal
10	Wheel speed sensor line
11	DSC control unit
12	Body Domain Controller (BDC)

For the measured tire pressures to be displayed at the Central Information Display (CID), the TPMS must have successfully completed a wheel assignment with the assistance of a teach-in operation. The teach-in operation comprises the following two phases.

Phases of the teach-in operation:

- Checking and storing the ID numbers of the tire pressure sensors assigned to the vehicle. Once the ID numbers have been successfully stored, the system is capable of issuing warnings. However, tire pressures still cannot be displayed.
- Determine and store the various installation positions of the tire pressure sensors. Once the installation position has been successfully stored, the system is capable of issuing warnings and displaying tire pressures via the (CID).

The teach-in operation starts automatically when the journey commences providing a standstill period of 8 min has been exceeded and cannot be influenced manually. The DSC control unit (11) launches a program as soon as the teach-in operation is active and serves to assign the wheels to the tire pressure sensor. In doing so, the wheel speed signals (9) from the wheel speed sensors (7) are compared with the messages (3) sent from the tire pressure sensor. As both signals are only available during the journey, this process must be performed dynamically. It is not possible to teach in when the vehicle is at a standstill.

Each of the four wheel speed sensors (7) is connected to the DSC control unit via a hard-wire connection. This connection is generally referred to as a wheel speed sensor line (10). Each wheel speed sensor line connection with the DSC control unit is different. The different connections are referred to as channels. Each channel is assigned to the installation position of one of the four wheel bearing units.

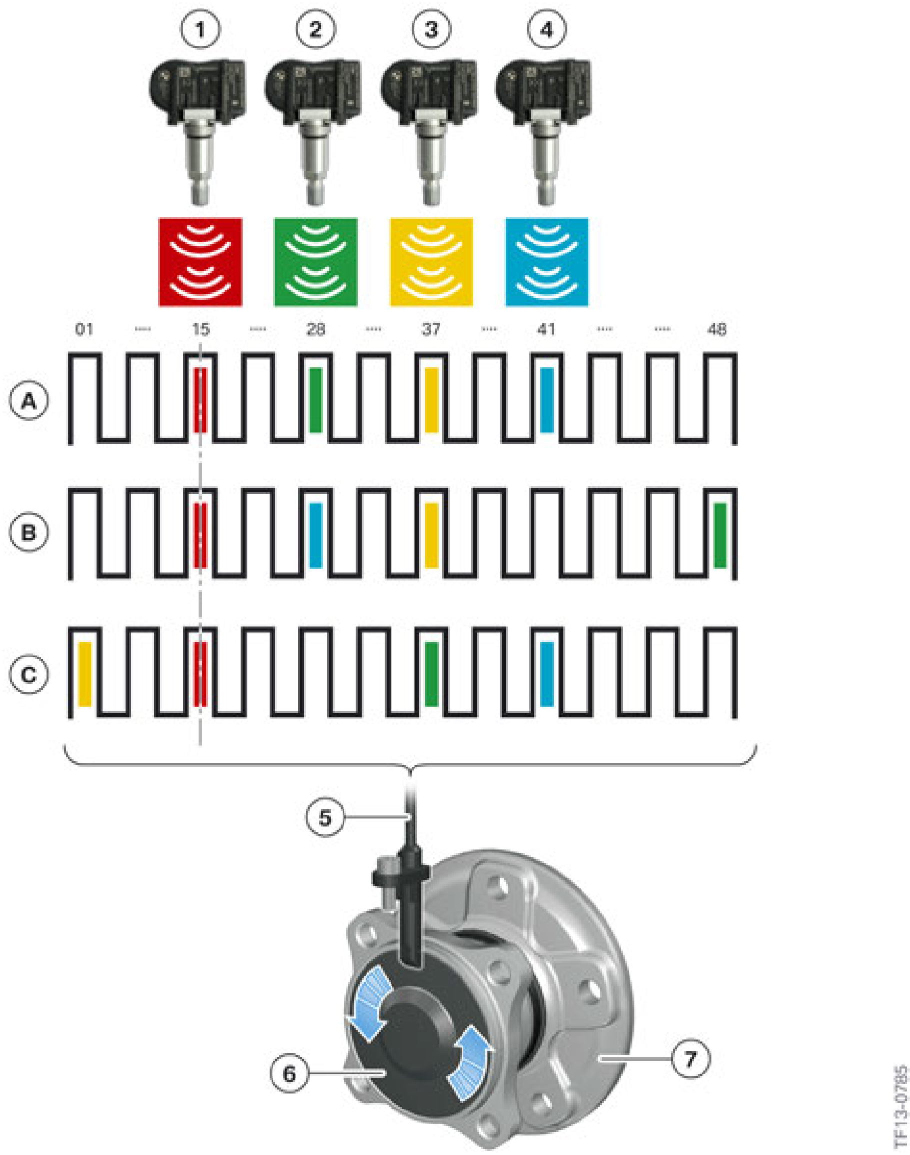
The channels are differentiated as follows:

- Front axle on left
- Front axle on right
- Rear axle on left
- Rear axle on right.

As each of the wheel speed signals are only imported via the channel assigned to them, the DSC control unit knows the installation location of the wheel bearing unit (8).

The four wheel bearing units are permanently bolted to the four wheels. If the wheels now turn at different wheel speeds (9) during cornering, the DSC control unit can determine the wheel speed and installation position of the four wheels based on the channel assignment.

The four different messages (3) from the tire pressure sensor must now be assigned to the appropriate wheel speed signal (9) and therefore the correct wheel. In teach-in mode, the messages (3) are only sent to the tire pressure sensors at a defined interval in the 12 o'clock position. This means that, although the four messages (3) are transmitted at different times, each wheel always transmits in the same position (12 o'clock). As a result, the following correlations exist between the wheel speed signal (9) and messages (3):



I01 Assignment of a tire pressure sensor

Index	Explanation
A	Assignment of increments during the first message
B	Assignment of increments during the second message
C	Assignment of increments during the third message
1	Tire pressure sensor with ID 1

3. Wheels

Index	Explanation
2	Tire pressure sensor with ID 2
3	Tire pressure sensor with ID 3
4	Tire pressure sensor with ID 4
5	Wheel speed sensor
6	Multi-pole sensor gear for ABS sensor
7	Wheel bearing unit front right

The multi-pole sensor gear of the ABS sensor (6) is subdivided into 48 increments. The DSC control unit can use the number of increments to determine the number of wheel rotations. The first increment is randomly specified at the start of the journey. The DSC control unit now counts each subsequent increment. The wheel has turned exactly one revolution once 48 increments have been counted.

In teach-in mode, the messages transmitted are assigned an increment from between 1 and 48. After the start of the journey, the DSC control unit receives one message from each of the tire pressure sensors at staggered time intervals. The message and increment are assigned to one another if they arrive at the same time. An example of three successive increment assignment process for a wheel (A, B, C) is shown in the above graphic. This process runs simultaneously for all four wheels. However, to simplify the illustration, only the wheel at the front right wheel bearing unit (7) is considered.

A maximum of 40 messages are transmitted in teach-in mode. The assignment must subsequently be complete. Of the 40 messages in total only 3 are shown in this example.

Assignment of increments during the first message (A):

- Tire pressure sensor with ID 1 transmits at increment 15
- Tire pressure sensor with ID 2 transmits at increment 28
- Tire pressure sensor with ID 3 transmits at increment 37
- Tire pressure sensor with ID 4 transmits at increment 41.

Assignment of increments during the second message (B):

- Tire pressure sensor with ID 1 transmits at increment 15
- Tire pressure sensor with ID 2 transmits at increment 48
- Tire pressure sensor with ID 3 transmits at increment 37
- Tire pressure sensor with ID 4 transmits at increment 28.

Assignment of increments during the third message (C):

- Tire pressure sensor with ID 1 transmits at increment 15
- Tire pressure sensor with ID 2 transmits at increment 37
- Tire pressure sensor with ID 3 transmits at increment 01
- Tire pressure sensor with ID 4 transmits at increment 41.

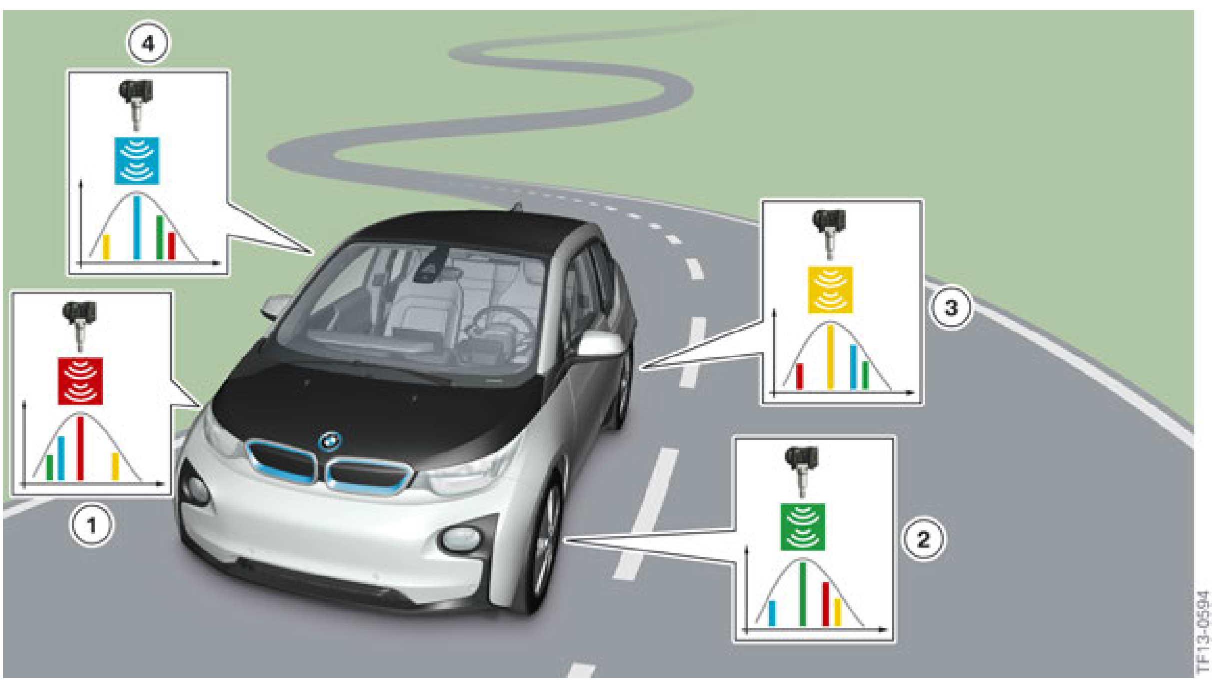
Following evaluation of the three increment assignments (A, B, C) it is noticeable that only the tire pressure sensor with ID 1 is always transmitting at the same increment. The messages of the other three tire pressure sensors are each being transmitted at different increments.

The IDs are shifting to the increments for the following reasons:

- Differences in speed during cornering
- Slip of wheels during straight-ahead driving and cornering.

If a tire pressure sensor always sends at the same increment, this means it has a fixed mechanical connection with the wheel bearing unit of the wheel speed sensor. If a change in speed or slip occurs at the wheel it therefore has no effect. In our example, the tire pressure sensor with ID 1 (1) has a fixed connection with the front right wheel bearing unit (7).

The wheel assignment for the tire pressure sensor with ID 1 is complete as the installation location front right has been identified.



I01 Tire pressure sensor teach-in process

Index	Explanation
1	Tire pressure sensor ID 1
2	Tire pressure sensor ID 2
3	Tire pressure sensor ID 3
4	Tire pressure sensor ID 4

The above graphic shows an example of a completed teach-in process.

It was possible to assign the tire pressure sensor as follows:

- Tire pressure sensor ID 1 to front axle right
- Tire pressure sensor ID 2 to front axle left
- Tire pressure sensor ID 3 to rear axle left
- Tire pressure sensor ID 4 to rear axle right.

It is possible to speed up the teach-in process by driving a winding route. This is because there is a much greater difference between wheel speeds during cornering when compared to straight-ahead driving.

During the teach-in process, the vehicle must be driven for a few minutes at a speed higher than 30 km/h.

Faults in the tire pressure sensor of other vehicles are avoided as this process takes place dynamically during the journey.

The tire pressures can be displayed in the CID as soon as the wheel assignment of all tire pressure sensors is complete.

3.3.4. Transmission cycles of the tire pressure sensors

The tire pressure sensor can be in three different modes. Sleep mode, teach-in mode or standby mode. The tire pressure sensors transmit their messages at different time intervals in teach-in and standby mode.

To ensure that the wheel assignment works, a message is transmitted in teach-in mode at 16 s intervals when the tire pressure sensors are at the 12 o'clock position. How long the teach-in mode lasts depends on a number of factors.

Factors influencing the duration of teach-in mode:

- Tire pressure sensor IDs already identified
- Tire pressure sensor IDs still unidentified
- Route
- Speed.

Teach-in mode may therefore last from a few seconds up to 10 minutes at the most. The tire pressure sensor then switch to standby mode and transmit a message at 64 s intervals in any position. Standby mode remains active until the tire pressure sensors switch to sleep mode. The reduced transmission frequency in standby mode increases the battery service life of the tire pressure sensors while the high transmission frequency in teach-in mode ensures that the wheels are quickly assigned.

The different modes of the tire pressure sensors can only be influenced to a limited extent. The following factors affect the modes.

Influences on the modes:

- When the wheel is stationary the tire pressure sensor switches to sleep mode
- Following a standstill period of > 8 min, the tire pressure sensors begin transmitting in teach-in mode when the journey starts
- Once teach-in mode has been successfully completed, or following a standstill period of < 8 min, the tire pressure sensors transmit in standby mode when the journey starts.

In order to rule out user errors, the TPMS operates fully automatically. Only the tire pressure initialization must be performed by the user manually. This gives rise to the following special aspects in Service.

As soon as the vehicle is stopped, the TPMS is locked for 8 min in total. The positions of the tire pressure sensors are therefore permanently stored in the DSC control unit and cannot be changed. This prevents a teach-in process from being started each time the vehicle stops. As a wheel change within 8 min is highly unlikely, the tire pressure sensors transmit in standby mode once the journey starts. The tire pressures displayed are based on the wheel assignments most recently taught in. New tire pressure sensors with unknown identification numbers ID are not taken into consideration and cannot be taught in with this system status.

If the standstill period is greater than 8 min, the positions of the wheels may have changed or new wheels with different tire pressure sensor may have been installed. If the system was not to respond to this state, a possible consequence would be that a puncture could not be detected or that the warning would be based on an incorrect installation position. For this reason, following a standstill period of > 8 min the tire pressure sensors transmit in teach-in mode at a driving speed of roughly 30 km/h. Parallel to this, the DSC control unit starts the wheel assignment program. It takes less time to teach in an ID of the tire pressure sensor that is already known than it would to teach in a new unknown ID.

When changing a wheel of the I01, make sure that the vehicle is **stationary** for at least **8 min** before initializing the tire pressures.

3.3.5. Functional prerequisites

To ensure that the TPMS issues correct a warning in the event of a pressure drop, an initialization with the tire pressures set correctly must be performed manually.

Prerequisites for an initialization are:

- All four wheels equipped with correct version of tire pressure sensor
- Sufficient energy in the batteries of the tire pressure sensors
- Prescribed tire pressures at all four wheels.

An initialization can be started at any time. However, it is only performed upon completion of the wheel assignment by the TPMS .

The following threshold values are stored in the system:

- Initialization threshold; when the minimum pressure of 2.0 bar is undercut during initialization the “Tire pressure too low” warning is issued
- First warning threshold value with a pressure drop of 20 % compared to the initialized nominal pressure
- Second warning threshold when 1.6 bar is undercut.

3.3.6. Initializing the tire pressure monitoring system (TPMS)

The TPMS is initialized via the iDrive menu.

The tire pressures must be initialized if:

- The tire pressures have been changed
- A tire change has been carried out
- The tire pressure sensor have been exchanged.

The initialization ends with a journey that can be interrupted at any time. When the journey continues, the process is automatically resumed. In order to complete it, a speed of more than 30 km/h must be attained. If no measuring results are available, the wheels in the Central Information Display will be displayed grey. A progress bar appears in the CID during the initialization process. Once the initialization has been completed successfully, all four wheels will be displayed green with the corresponding tire pressures.

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To ensure the system works reliably, an initialization must be performed following each wheel change or tire pressure adjustment.

3.3.7. Information in Central Information Display

As the tire pressure sensor are in sleep mode when the vehicle is at a standstill, the actual tire pressures cannot be queried via the Central Information Display. As soon as the vehicle is in motion and exceeds a speed of roughly 30 km/h, the tire pressure sensors start transmitting. If the identification numbers ID are stored in the DSC control unit, the tire pressures can be displayed in the CID.

The tire and system statuses are indicated by different colors of wheels and a text message. The following illustration shows how the different system statuses are displayed in the CID.

I01 TPMS messages in the CID

Index	Explanation
1	Loss of pressure in one or several tires
2	Loss of pressure in all tires
3	Tire pressures within the permissible tolerance
4	Tire pressures OK
5	Tire pressures are being initialized
6	Loss of pressure in front left tire
7	TPMS dropped out

1 **All wheels orange, without tire pressure**

- The identification numbers of the tire pressure sensor are known
- The positions of the tire pressure sensor have not been taught in
- The tire pressures are not displayed
- Text message: tire pressure loss. Fill tires correctly
- Loss of pressure in one or several tires.

2 **All wheels orange, with tire pressure**
- The identification numbers of the tire pressure sensor are known
- The positions of the tire pressure sensor have been taught in
- The tire pressures are displayed
- Text message: “Tire pressure loss”. Fill tires correctly
- Loss of pressure in all tires.

3 **All wheels green, without tire pressure** (teach-in operation active)
- The identification numbers of the tire pressure sensor are known
- The positions of the tire pressure sensor have not been taught in
- Tire pressure monitoring active
- Tire pressures within the permissible tolerances.

4 **All wheels green, with tire pressure**
- The identification numbers of the tire pressure sensor are known
- The positions of the tire pressure sensor have been taught in
- Tire pressure monitoring active
- Tire pressures OK.

5 **All wheels grey** (teach-in operation active)
- The identification numbers of the tire pressure sensor are being taught in
- The positions of the tire pressure sensor are being taught in
- Text message: TPMS reset is being performed.

6 **Three wheels green, with tire pressure**
- The identification numbers of the tire pressure sensor are known
- The positions of the tire pressure sensor have been taught in
- Text message: “Tire pressure loss front left. Fill tires correctly”
- Loss of pressure in one tire.

7 **All wheels grey**
- Text message: “Tire pressure monitoring dropped out”.

When installing new tire pressure sensor IDs, an initialization must be started manually. If this initialization has not been performed, the driver will be prompted via the iDrive menu to do so once the journey has started.

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Possible factors that prevent the tire pressures being displayed in the Central Information Display:

- Wheel standstill before a journey starts
- Incorrect version of tire pressure sensor
- Battery capacity depleted

- Wheel assignment of tire pressure sensor not complete
- Tire pressure sensor faulty
- Internal fault in DSC control unit.

3.3.8. Information in the instrument cluster (KOMBI)

The yellow warning light on the puncture display informs the driver about various system statuses.

I01 Yellow warning light of puncture display

If the warning light lights up continuously, this indicates that there may be problems with the tire pressure.

This could be due to one of the following causes:

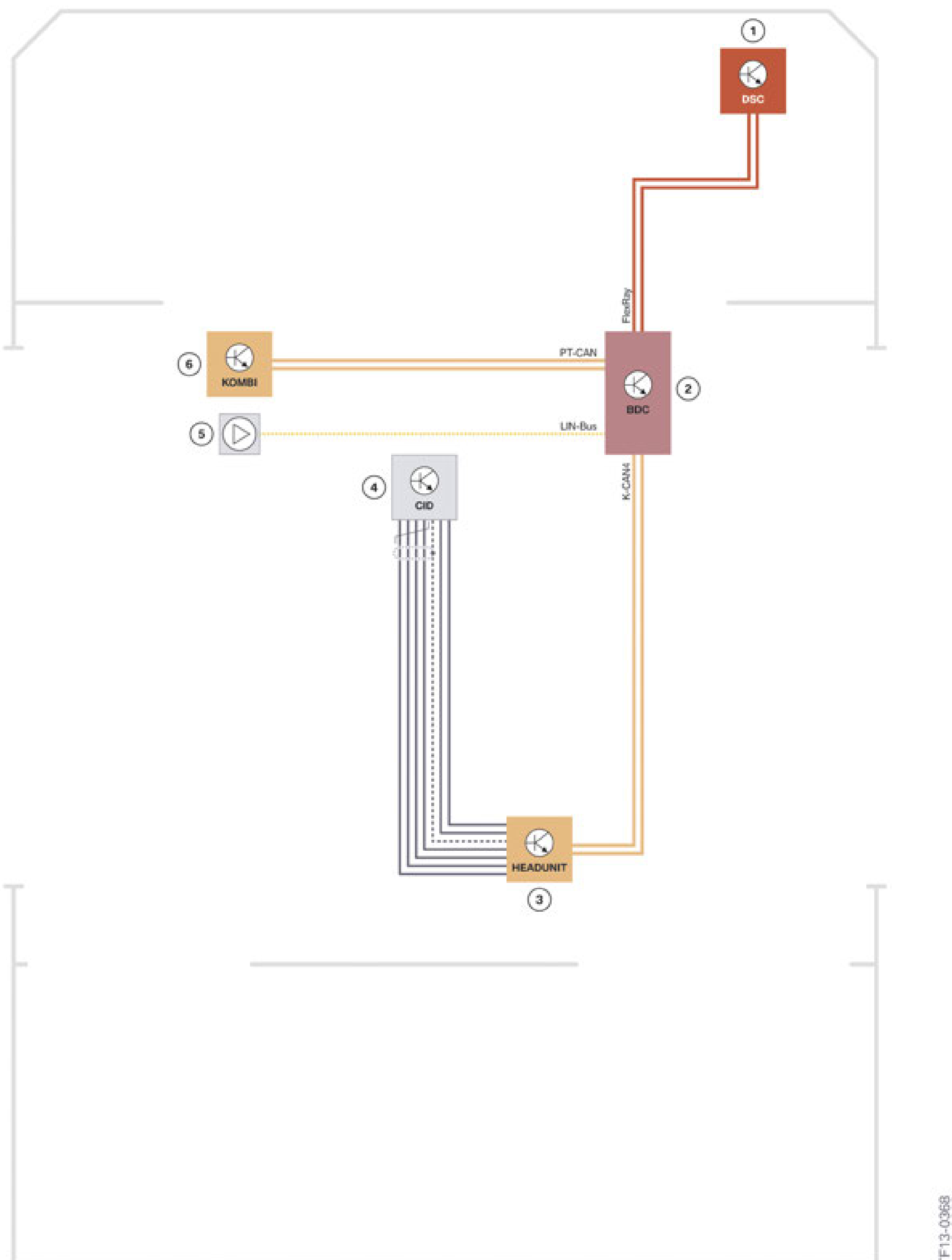
- A puncture or more significant loss of pressure
- The system has not been initialized and its warning is based on the old status.

If a warning light flashes then lights up continuously this indicates a malfunction.

This could be due to one of the following causes:

- Wheel mounted without tire pressure sensor
- TPMS could not complete the initialization process
- Faults in transmission frequencies of tire pressure sensor.

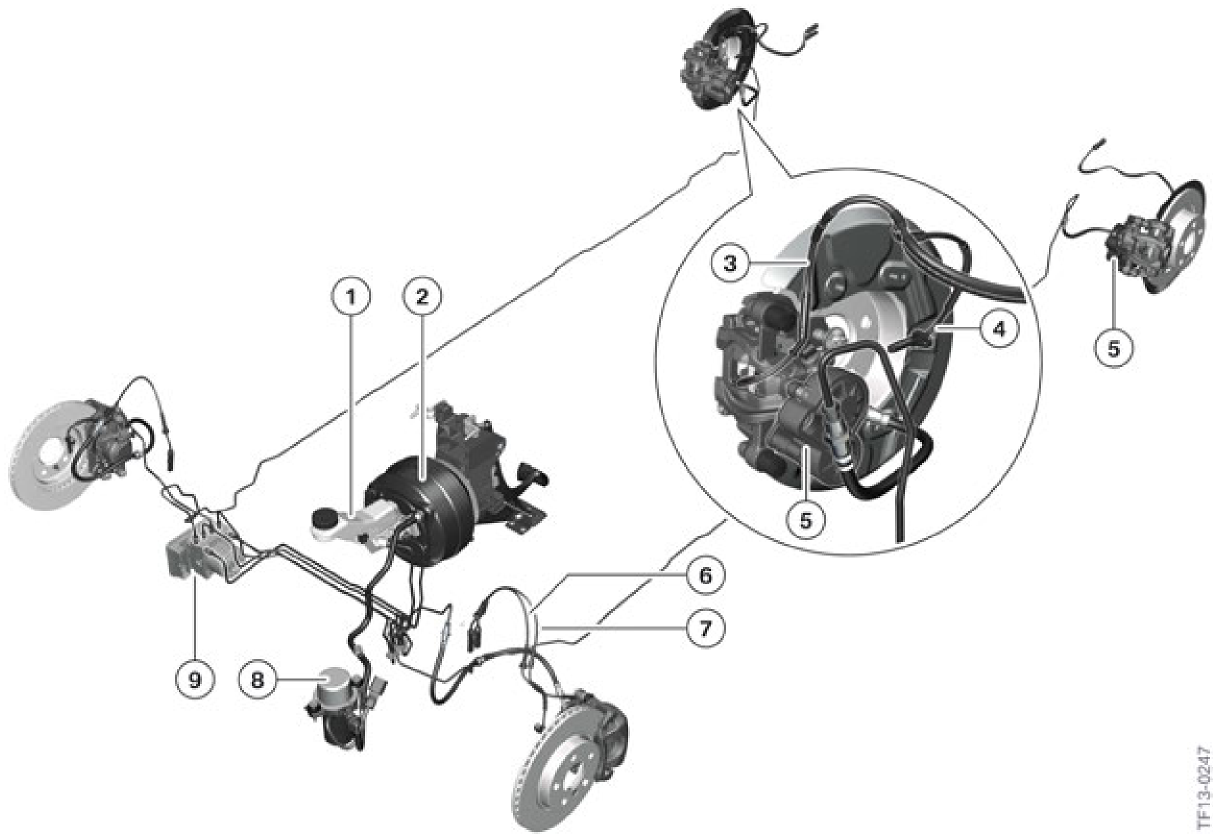
3.3.9. System wiring diagram



I01 System wiring diagram of tire pressure monitoring TPMS

Index	Explanation
1	Dynamic Stability Control (DSC)
2	Body Domain Controller (BDC)
3	Head unit
4	Central information display (CID)
5	Remote control receiver (FBD)
6	Instrument panel (KOMBI)

4. Braking System



I01 Overview of braking system

Index	Explanation
1	Brake fluid expansion tank
2	Brake servo
3	Brake pad wear sensor, rear axle
4	Wheel speed sensor, rear axle
5	Electromechanical parking brake actuator
6	Brake pad wear sensor, front axle
7	Wheel speed sensor, front axle
8	Electric vacuum pump
9	Dynamic Stability Control (DSC)

Internally ventilated brake discs are used on the front axle of the I01. Due to the low thermal loads, the brake discs on the rear axle do not have internal ventilation. It has been possible to reduce the weight of the brake discs and brake pads by using less material. Normally, if less material is used the service requirements are higher as the components reach their wear limits more quickly.

By harmonizing the accelerator pedal operation with the I01, braking decelerations of up to 1.6 m/s² can be performed purely electrically and thus wear-free via the electrical machine. This means that the wear of the brake discs and brake pads will be extremely low, providing a forward-thinking driving style is adopted. The reduction in weight in turn has a favorable effect on the range.

4. Braking System

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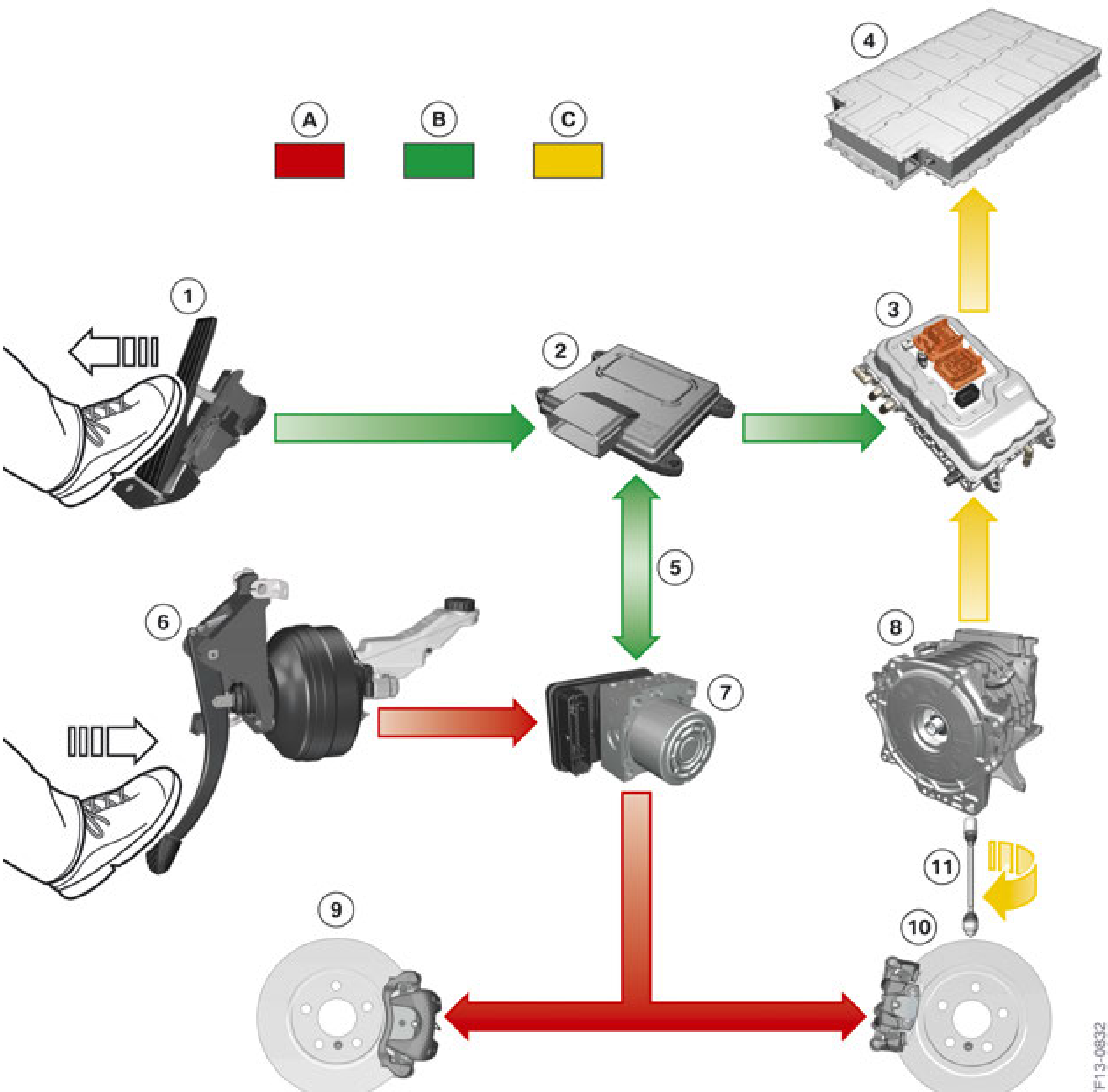
Currently, the rear brake discs of the I01 must also be replaced when the brake pads are worn. For the applicable procedure for exchanging the brake discs and brake pads, please refer to the current repair instructions.

4.1. Braking energy recycling



I01 System overview, brake energy regeneration

4. Braking System

Index	Explanation
A	Hydraulic braking
B	Signal path
C	Recuperative braking
1	Accelerator pedal module
2	Electrical Digital Motor Electronics (EDME)
3	Electric motor electronics (EME)
4	High-voltage battery unit
5	Separate interface between EDME and DSC
6	Brake pedal with brake booster
7	Dynamic Stability Control (DSC)
8	Electric motor
9	Front wheel brake
10	Rear wheel brake
11	Output shaft

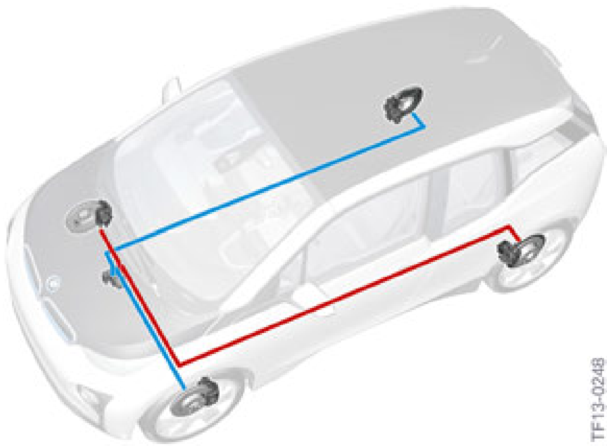
In contrast to current hybrid vehicles, the I01 is not equipped with a brake pedal angle sensor. Due to the special accelerator pedal operation, the electrical machine (8) is regeneratively actuated by the electrical machine electronics EME (3) when exiting the accelerator pedal module (1). This means that the wheels at the rear axle of the I01 now drive the electrical machine, which now acts as the generator, via the propeller shafts (11). The resulting torque of the electrical machine acts on the wheels of the rear axle to produce a tangible deceleration. The brake pedal does not have to be operated during process. The energy produced is stored in the high-voltage battery unit (4) via the EME. This means that, in contrast to the current hybrid vehicles, the recuperative braking (C) is controlled via the accelerator pedal module and not via the brake pedal. Hydraulic braking (A) is possible using the brake pedal only.

The Electrical Digital Motor Electronics control unit (EDME) (2) requests and controls the recuperative braking (C). If the accelerator pedal module is fully released during the journey, the EDME determines the maximum energy recovery according to the driving condition. With maximum energy recovery the vehicle is decelerated with 1.6 m/s^2. The request is transmitted to the EME via the PT-CAN2. The EME now controls the electrical machine according to the specifications of the EDME.

The EDME has a separate interface (5) with the FlexRay data bus. The Dynamic Stability Control (DSC) (7) can be found in this bus system. The task of the DSC is to detect unstable driving conditions and take appropriate measures to keep the vehicle safely on course. When an unstable driving situation is detected during energy recovery, the DSC transmits information on an imminent critical driving condition via the separate interface (5). The EDME determines how the maximum energy recovery is to be adapted to the critical driving condition and transmits the request accordingly to the EME. Based on this request, the EME reduces the energy recovery and therefore the deceleration. This control is referred to as engine drag torque control (MSR).

As with conventional braking systems, when the brake pedal is operated in the I01, pressure builds up in the hydraulic system of the dual-circuit brake system. The braking of the vehicle is now based entirely on energy recovery by the electrical machine and operation of the wheel brakes.

4.2. Service brakes



I01 Diagonal split brake system

The I01 features a hydraulic dual-circuit brake system with diagonal split. With this split braking system, the front brake on the left together with the rear brake on the right and front brake on the right together with the rear brake on the left respectively are combined into one brake circuit.

4.2.1. Fuel level sensor

I01 Fill level sensor in expansion tank

The fuel level sensor of the brake fluid expansion tank has been moved from the sealing cap to the expansion tank. The sealing cap is now no longer permanently connected to the vehicle via a cable. This means the sealing cap can be put in a safe place when filling the expansion tank.

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Brake fluid poses a danger to health when it comes into contact with the skin and/or is swallowed. Wear protective gloves and safety goggles when handling brake fluid. Avoid contact with the eyes and skin.

Brake fluid destroys paint. Make sure when filling the brake fluid expansion tank that brake fluid does not come into contact with the surface of the vehicle.

Mineral oils can damage the rubber seals of the brake system. You must therefore not use extractors containing mineral oils when drawing off excess brake fluid.

4.2.2. Brake circuit bleeding

Until now, the hydraulics of the brake system in BMW vehicles were bled via the BMW diagnosis system ISTA following the exchange of the DSC unit using a special brake bleeding procedure. This measure was necessary to ensure that no air was left in the DSC unit. Various valves and the return pump were actuated in a precisely defined sequence during the brake bleeding procedure in order to support the bleeding process.

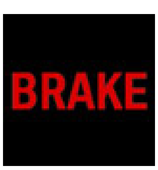
It has been possible to omit a brake bleeding procedure in the I01 by ensuring that the DSC hydraulic control units are perfectly pre-filled. The hydraulics of the brake system in the I01 must simply be bled conventionally once the DSC unit has been exchanged, without using the BMW diagnosis system. This saves time and reduces costs for the Service of the I01.

For the detailed procedure when exchanging the DSC unit, refer to the current repair instructions.

4.2.3. Brake pad wear indicator

The I01 is currently not equipped with a Condition Based Service display for brake pad wear. The remaining brake pad thickness must therefore be determined manually in Service. Single-stage brake pad wear sensors are installed on the front left and rear right wheel brakes. As soon as the conductor path of the brake pad wear sensor has worn out due to reaching its wear limit, a Check Control symbol is displayed for the driver in the instrument cluster (KOMBI). Once the wear limit has been reached, roughly 5 % (range of roughly 2000 km) of the brake pad thickness is available.

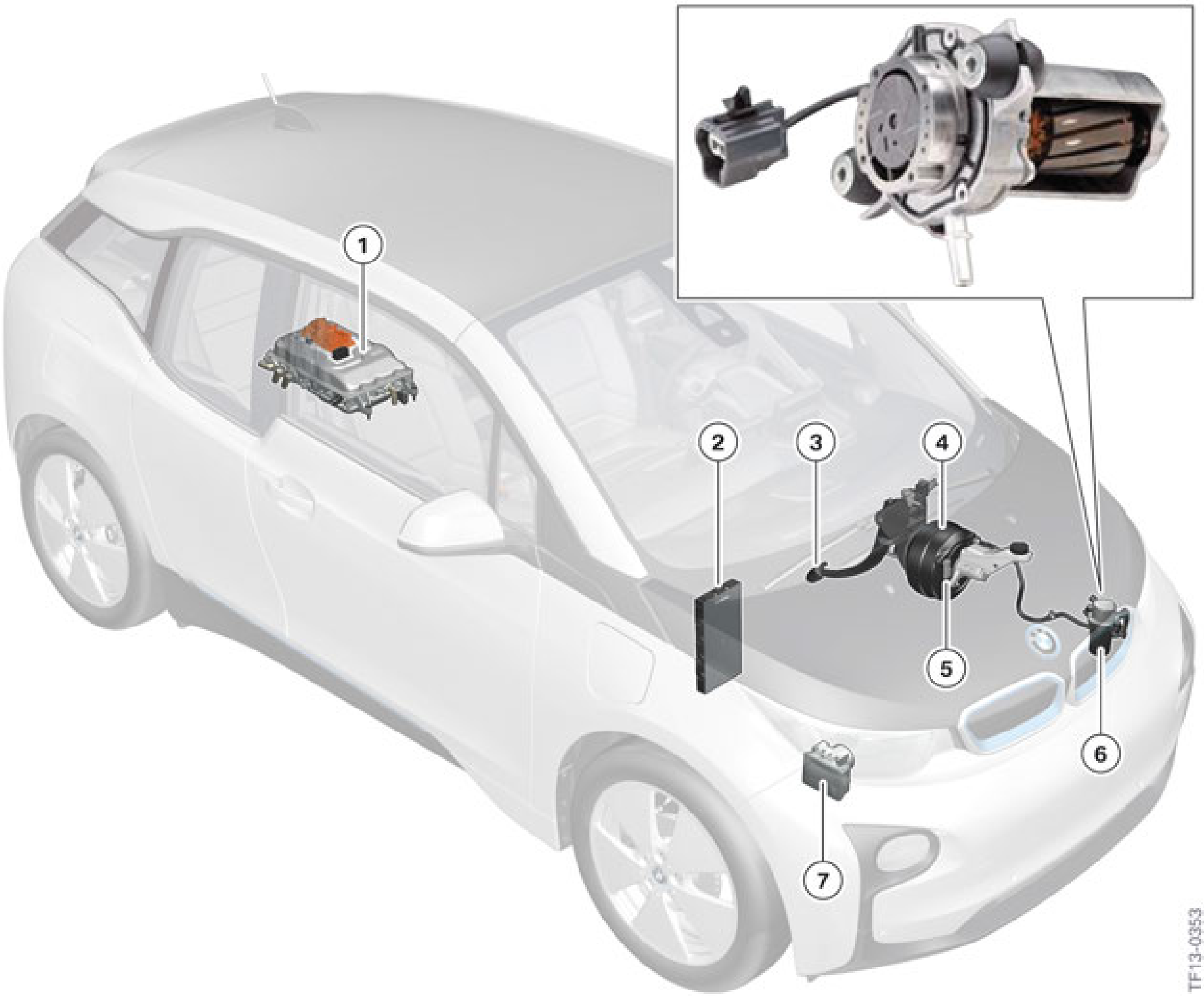
The Check Control symbol is displayed in red with the text message "Brake" in the US market once the brake pad wear limit has been reached.



I01 US Check Control symbol upon reaching the brake pad wear limit

A note appears in the CID in addition to the warning lights.

4.2.4. Brake vacuum supply



I01 Overview of brake vacuum supply

Index	Explanation
1	Electric motor electronics (EME)
2	Body Domain Controller (BDC)
3	Brake pedal
4	Brake servo
5	Brake vacuum pressure sensor
6	Electric vacuum pump
7	Dynamic Stability Control (DSC)

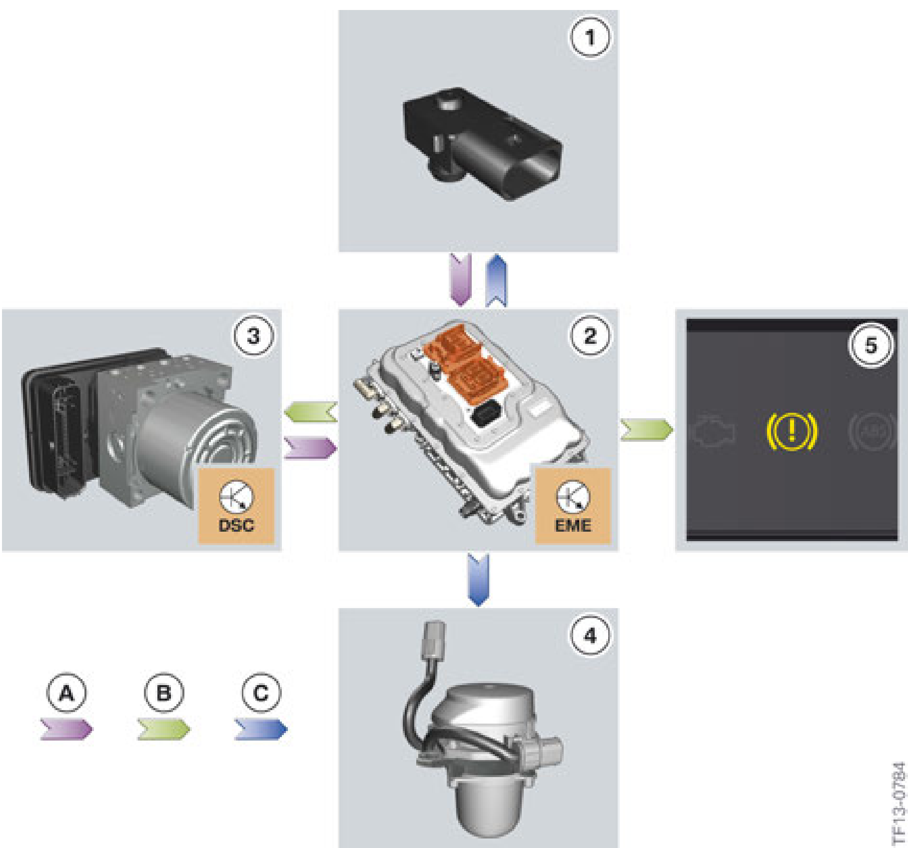
The brake pedal force of the brake pedal (3) is supported by using a brake servo (4). The necessary vacuum for the brake servo is generated according to the requirements by an electrical vacuum pump (6). To ensure that sufficient brake power assistance is available at all times, a brake vacuum sensor (5) is fitted to the brake servo of the I01 in order to monitor the available vacuum.

4. Braking System

The brake vacuum sensor is designed as a differential pressure sensor that measures the existing vacuum in the brake servo relative to existing atmospheric pressure. The sensor operates according to the strain gauge principle. There are three electrical connections at the brake vacuum sensor. The 5 V voltage supply, the ground connection and the signal line. The extent of deformation of the strain gauges varies depending on the vacuum in the brake servo. Their resistance changes, depending on the extent of deformation. This means that the resistance increases and the signal voltage decreases as the vacuum increases.

The electrical machine electronics EME (1) evaluates this signal for the purpose of activating the electrical vacuum pump according to the requirements. This requirements-oriented activation saves energy and therefore contributes towards extending the range of the vehicle.

If a fault develops, this is communicated to the Dynamic Stability Control (7). In this case, communication between the electrical machine electronics EME and the DSC is effected via the Body Domain Controller (BDC) (2).



I01 Signal shape of brake vacuum supply

Index	Explanation
A	Information input
B	Information output
C	Voltage output
1	Brake vacuum pressure sensor

Index	Explanation
2	Electric motor electronics (EME)
3	Dynamic Stability Control (DSC)
4	Electric vacuum pump
5	Instrument panel (KOMBI)

The brake vacuum sensor (1) receives voltage from the electrical machine electronics EME and sends back a voltage signal which depends on the vacuum in the brake servo. This analog sensor signal is processed by the EME which decides based on the sensor signal and various dynamic handling characteristics, such as the driving speed, whether the vacuum pump is to be switched on. In addition, the function logic in the EME takes a hysteresis into account so that the electrical vacuum pump is not continuously switched on and off. Instead, it remains switched on until the brake vacuum reaches a required minimum level.

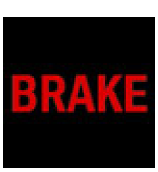
The EME incorporates an output stage (semiconductor relay) which assists with switching the 12 V supply voltage of the electrical vacuum pump on and off. When switching on, the output voltage of the DC/DC converter is connected directly to the electrical vacuum pump. Switch-on currents of up to 30 A can occur during this process. To protect the output stage and the cable, the current level is limited electronically. The power or speed of the electrical vacuum pump is not controlled. Instead, it is only switched on and off.

System faults can have the following consequences:

- When the brake vacuum sensor malfunctions, the EME receives no information about the vacuum in the brake servo. The electrical vacuum pump is now activated based on information such as the brake pressure or the brake light switch from the Dynamic Stability Control. As requirements-oriented control is no longer possible without the sensor signal from the brake vacuum sensor, the EME switches the electrical vacuum pump on and back off according to a time pattern when it detects a braking requirement.
- If the electrical vacuum pump malfunctions, there is no other option for the EME to create a vacuum for the brake servo. When a braking request is detected, a DSC subfunction is then activated to compensate for the lack of brake power assistance. A hydraulic (instead of vacuum-based) brake-servo assistance is now being implemented with the help of the DSC. This DSC function is activated automatically.

If system faults occur, the EME arranges for a Check Control message to be displayed at the instrument cluster (KOMBI) to inform the driver about the fault status.

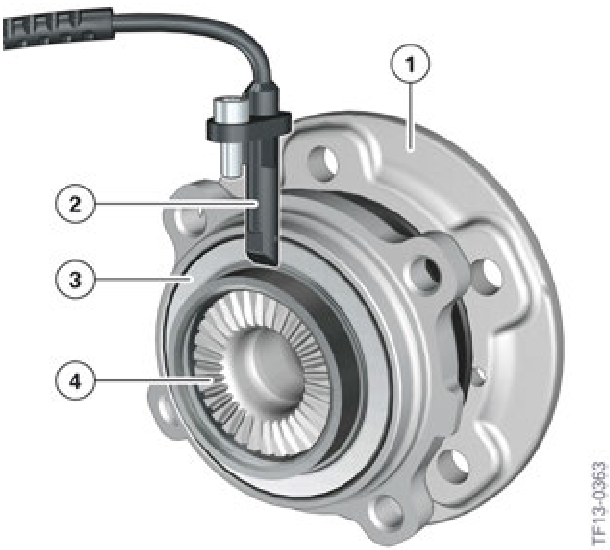
In the US version, system faults are indicated by the symbol shown below.



I01 Check Control symbol for US version when the vacuum supply malfunctions

If this fault occurs, the brake pedal travel and brake pedal force are not the same as they would be in the normal condition. However, the customer can still decelerate the vehicle safely using the brake power assistance, and also use the DSC if required for stabilizing interventions.

4.2.5. Wheel speed sensor



I01 Wheel bearing unit

Index	Explanation
1	Wheel bearing unit
2	Wheel speed sensor
3	Multi-pole sensor gear
4	Spur gearing

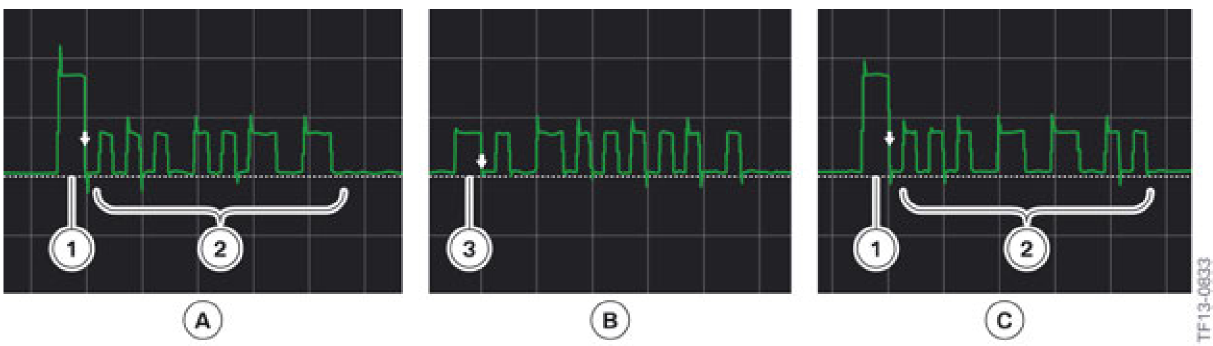
Although initially inductive sensors were predominantly used to determine the wheel speeds for an ABS control operation in older vehicles, currently the significance of active sensors are increasing more and more. Wheel speed signals are not just used for an ABS control operation, they are also used by a large number of other systems such as the engine, transmission, navigation, or suspension control systems. The I01 is equipped with four active wheel speed sensors (2) which the DSC control unit can use to determine the current wheel speeds. The wheel bearing unit (1) can only be replaced completely. This means it is no longer possible to mix-up the installation position of the multi-pole sensor gear (3). The active wheel speed sensor captures the speed and, depending on the equipment specification (see the following table), also the direction of rotation of the multi-pole sensor gear. With the active wheel speed sensors a distinction is made between sensors with and sensors without rotational detection.

The hole pattern of the wheel hub on the wheel bearing unit is 5 x 112 mm. Due to the new hole-circle diameter, Service requires a modified clamping adapter to clamp the wheel rims on a balancing machine.

The drive shaft is connected to the wheel bearing unit via the spur gearing (4).

The table below provides an overview of the different wheel speed sensors that are available with the various equipment specifications.

	Wheel speed sensor Front axle	Wheel speed sensor Rear axle
Basic version of equipment	Without rotational direction detection	Without rotational direction detection
Parking Maneuvering Assistant (PMA)	With rotational direction detection	With rotational direction detection
Active cruise control (ACC) with Stop&Go function	With rotational direction detection	With rotational direction detection



I01 Wheel speed signal with rotational direction detection

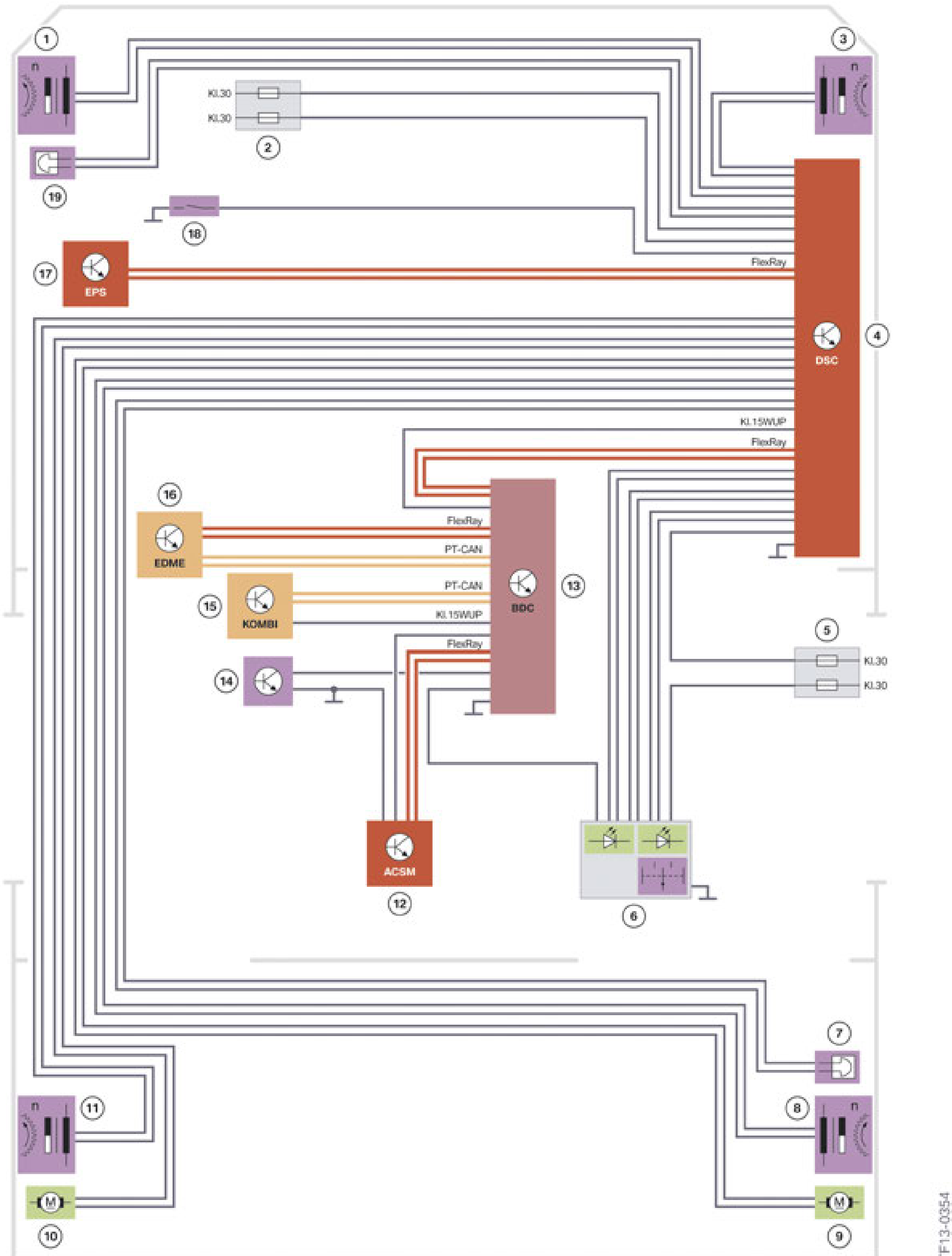
Index	Explanation
A	Signal for driving forwards
B	Signal for wheel standstill
C	Signal for reversing
1	Information, wheel turning
2	Information, direction of rotation
3	Information, wheel at standstill

In order to perform their function, different assist systems require information on the wheel speed, wheel standstill (3) and the direction of rotation (2). This information is transferred from the wheel speed sensor with rotational direction detection to the DSC control unit using a data log (Manchester code). The information wheel turning (1) is output via a level of 28 mA. The information direction of rotation (2) is output via a level of 14 mA. If the wheel is stationary (3), the 28 mA level also falls to 14 mA. The wheel speed is determined via the signal frequency.

4.2.6. Brake test stand

If the vehicle is decelerated in traffic via the service brake, the braking power is the combined power of the electrical machine and service brake. For the wheels of the rear axle to turn freely on the brake test stand, the gear shift lever must be brought into the neutral position. The electrical machine is not activated in the neutral position and can run freely. This means that torques do not act on the drive train.

4.2.7. System wiring diagram



I01 Dynamic Stability Control (DSC) system wiring diagram

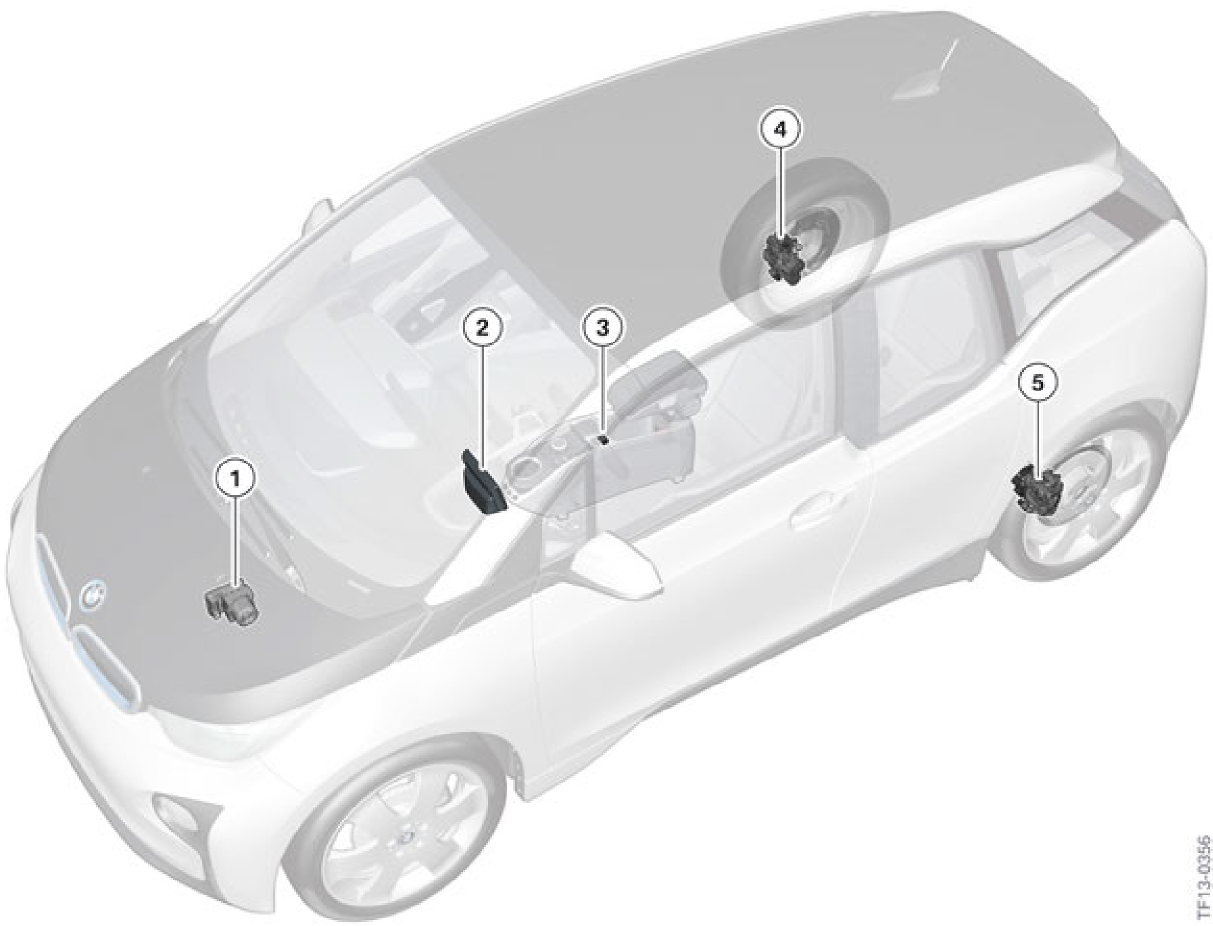
4. Braking System

Index	Explanation
1	Wheel-speed sensor, front left
2	Fuse, DSC hydraulic control unit
3	Wheel-speed sensor, front right
4	Dynamic Stability Control (DSC)
5	Fuse, parking brake button and DSC control unit
6	Parking brake button
7	Brake pad wear sensor, rear right
8	Wheel speed sensor, rear axle right
9	Electromechanical parking brake EMF actuator, rear axle right
10	Electromechanical parking brake EMF actuator, rear axle left
11	Wheel speed sensor, rear axle left
12	Crash Safety Module (ACSM)
13	Body Domain Controller (BDC)
14	Brake light switch
15	Instrument panel (KOMBI)
16	Electrical Digital Motor Electronics EDME
17	Electronic Power Steering (EPS)
18	Brake fluid level switch
19	Brake pad wear sensor, front left

4. Braking System

4.3. Parking brake

4.3.1. Overview



I01 Electromechanical parking brake EMF system overview

Index	Explanation
1	Dynamic Stability Control (DSC)
2	Instrument panel (KOMBI)
3	Parking brake button
4	Parking brake actuator, rear axle right
5	Parking brake actuator, rear axle left

The difference between the electromechanical parking brake of the I01 and the systems used up till now is that a separate control unit is not required. The electromechanical parking brake is activated via the DSC control unit (1). There is a parking brake button (3) on the center console for activating or deactivating the electromechanical parking brake. The driver is informed about the current system status via the instrument cluster (KOMBI) (2).

The brake pad is applied with a precisely calculated preload force via two actuators screwed to the brake calipers (4, 5). A temperature model is stored in the DSC control unit which makes it possible to draw conclusions about the brake disc temperatures. As the contact pressure reduces as the brake disc cools down, the system must retention the brake pads, particularly when a sporty driving style is adopted. The time and frequency of retentioning varies depending on the initial temperature calculated. When the electromechanical parking brake is opened, the actuators (4, 5) are only moved back until the brake pads reach the correct air gap setting. Due to this readjustment function, the actuators (4, 5) must be moved back before exchanging the brake pads in Service. For the detailed procedure, refer to the current repair instructions.

Advantages of an electromechanical parking brake:

- More storage space due to the omission of a parking brake lever and parking brake Bowden cable
- Contact pressure of brake pads correctly adjusted at all times
- Different additional functions for support of driver
- Higher braking power of auxiliary brake system.

4.3.2. Functions

Dynamic emergency braking

When using electrical parking brake systems, an emergency braking function is prescribed by law. This so-called auxiliary brake system must perform the function of the service brake system with reduced effectiveness if it fails. This does not have to be a third independent brake system; instead either the still intact brake circuit of a dual-circuit service brake or the parking brake can be used as an auxiliary brake. When using the parking brake this must however be gradual.

If the parking brake button is operated during the journey above a defined driving speed, the DSC unit initiates a dynamic emergency braking operation. The activation of the 2-piston pump and changeover valves in the DSC unit causes a pressure build-up at all four wheel brakes. The slip limits of all wheels are monitored with the assistance of the four wheel speed sensors to ensure a stable braking operation until the vehicle comes to a standstill. The two actuators of the electromechanical parking brake are activated as soon as the vehicle comes to a standstill. Now only the parking brake secures the vehicle to prevent it from rolling away.

An innovation of the dynamic emergency braking function, which is therefore being used for the first time with BMW, is that when the 2-piston pump in the DSC unit malfunctions a controlled deceleration of the vehicle takes place via the actuators of the electromechanical parking brake. Controlled deceleration means that the slip limits of the rear axle are monitored via the wheel speed sensors. If these are exceeded and an unstable driving situation occurs as a result, the actuators of the electromechanical parking brake of the DSC control unit are released until the performance values for slip at the rear wheels are once again stable. This new function contributes towards a further increase in driving safety for the customer.

Automatic release of the parking brake

This function allows the driver to drive off when the parking brake is applied without operating the parking brake button.

Prerequisites for automatic release of the electromechanical parking brake:

- All doors closed
- Driver's seat belt fastened
- Driving readiness established
- Electromechanical parking brake operated
- Drive position engaged
- Accelerator pedal operated.

4.3.3. Test stand mode

I01 Activation of test stand mode

Index	Explanation
1	Instrument panel (KOMBI)
2	Reset button
3	START-STOP button "terminal 15 on"
4	Press reset button for approx. 10 s
5	Press reset button briefly twice
6	Press reset button and hold pressed
7	Press reset button briefly

Brake test stands can serve as performance or brake test stands. When carrying out some checks, it may be necessary to activate the test stand mode, depending on the system being checked. The test stand mode can be activated via the instrument cluster (KOMBI) (1).

Procedure for activating the test stand mode:

- Terminal 15 on (3)
  Instrument cluster (KOMBI) is switched on (1)
- Press reset button for 10 s (2)
  The submenu for selection of different functions (4) subsequently appears
- Press reset button briefly twice (2)
  The test stand mode is now marked (5)
- Press reset button and hold pressed (2)
  Test stand mode is now selected (6)
- Press reset button briefly (2)
  The test stand mode is activated (7)

Once test stand mode has been activated, the text message "Test operation ends at the start of the journey" appears in the instrument cluster (KOMBI). When the test stand mode is activated, all DSC functions are deactivated. This is also displayed to the driver by the DSC indicator and warning light at the instrument cluster (KOMBI).

The test stand mode can be deactivated manually via a terminal change or automatically by exiting the test stand. Before the test stand mode is automatically deactivated, the steering angle, longitudinal acceleration and yaw rate of the vehicle are evaluated. When the stored values that would occur when driving normally are exceeded, test stand mode is switched off automatically. The text message "Test operation ends at start of the journey" goes out to indicate when test stand mode is deactivated. The full functionality of the DSC can only be restored by changing terminal.

I01 DSC indicator and warning light

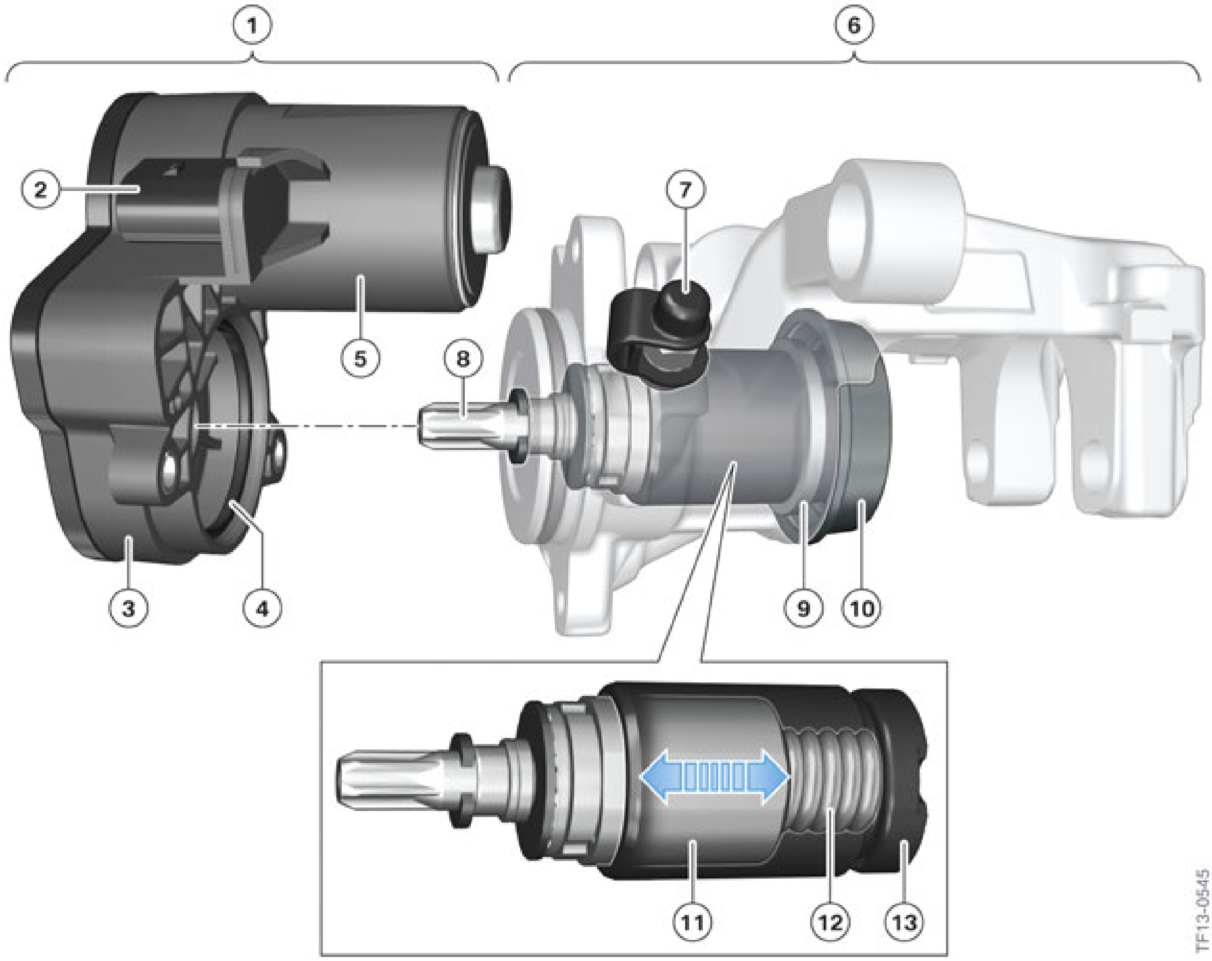
4.3.4. Brake test stand

The I01 has a test stand mode for checking the braking power of the electromechanical parking brake on a brake test stand. The test stand mode must be activated manually via the Service menu in the instrument cluster. Automatic rolling detection is not possible. When the test stand mode is activated, the vehicle is decelerated via the actuators of the electromechanical parking brake when the parking brake button is pressed. A DSC pressure build-up in all four wheel brakes does not occur. This makes it possible to determine the brake forces of the electromechanical parking brake.

Once test stand mode has been activated and the speed of the wheels on the rear axle is higher than 3 km/h, the system is in test stand mode. The parking brake indicator light of the electromechanical parking brake EMF acknowledges this status by flashing at a frequency of 1 hertz. The EMF can be engaged in five stages with the assistance of the parking brake button. In this case, the braking varies between the minimum braking power in the first stage and the maximum braking power once the parking brake button has been pressed five times. If the button is operated continuously, the system increases the braking power automatically incrementally up to the maximum braking power. The flashing frequency of the parking brake indicator light changes from 1 hertz to 3 hertz when the parking brake button is pressed in test stand mode.

I01 Parking brake indicator lamp

4.3.5. Service



I01 Overview of brake caliper, rear axle

Index	Explanation
1	Electromechanical parking brake actuator
2	Socket
3	Reduction gear in actuator housing
4	Gasket
5	Direct current motor
6	floating caliper
7	Vent valve
8	Spindle drive
9	Plain compression ring

Index	Explanation
10	Dust boot
11	Spindle
12	Recirculating ball thread
13	Brake piston

The Service employee can, with the assistance of the diagnosis system ISTA, put the electromechanical parking brake EMF in workshop mode. When workshop mode is activated, the spindle (11) in the floating caliper (6) is moved back as far as it will go. This allows the brake piston (13) to be turned back mechanically. The above figure shows the spindle and the brake piston moved back as for as they will go. The parking brake button is blocked to prevent injury due to incorrect operation in Service.

Exiting workshop mode:

- Manual
  The service employee deactivates the workshop mode manually via the service function.
- Automatic
  A driving speed of 5 km/h has been exceeded.

When carrying out various servicing tasks, it may be necessary to teach in the electromechanical parking brake EMF again by performing an initialization run.

The initialization run must be performed after carrying out the following work:

- Workshop mode has been exited
- The DSC control unit was replaced.

The purpose of the initialization run is to adjust the travel distance of the spindle in the floating caliper. This can be done manually without the assistance of the diagnosis system ISTA. For this, the parking brake button must be operated once when operating the foot brake. A "close-open-close" activation of the actuators of the electromechanical parking brake is subsequently performed. The control unit detects based on the power consumption when the brake pad is fully in contact with the brake disc. The spindle is then only opened wide enough to allow the brake disc to turn freely. In the final step, the parking brake is fully applied. If the footbrake is released during the initialization run, the initialization run stops and the note "Apply footbrake. Release parking brake. The initialization run must then be restarted. If the initialization run is not performed, the yellow parking brake indicator light lights up in the display.

I01 Parking brake indicator lamp

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The brake piston of the floating caliper brake must not be unscrewed. If the brake piston is unscrewed, the balls and springs of the recirculating ball thread will fall out and it will no longer be possible to reinstall them.

4.3.6. Emergency release

To release the electromechanical parking brake in emergencies, the actuator must be removed and the spindle turned back mechanically via the spindle drive. For details of the emergency release procedure for the electromechanical parking brake, refer to the current repair instructions.

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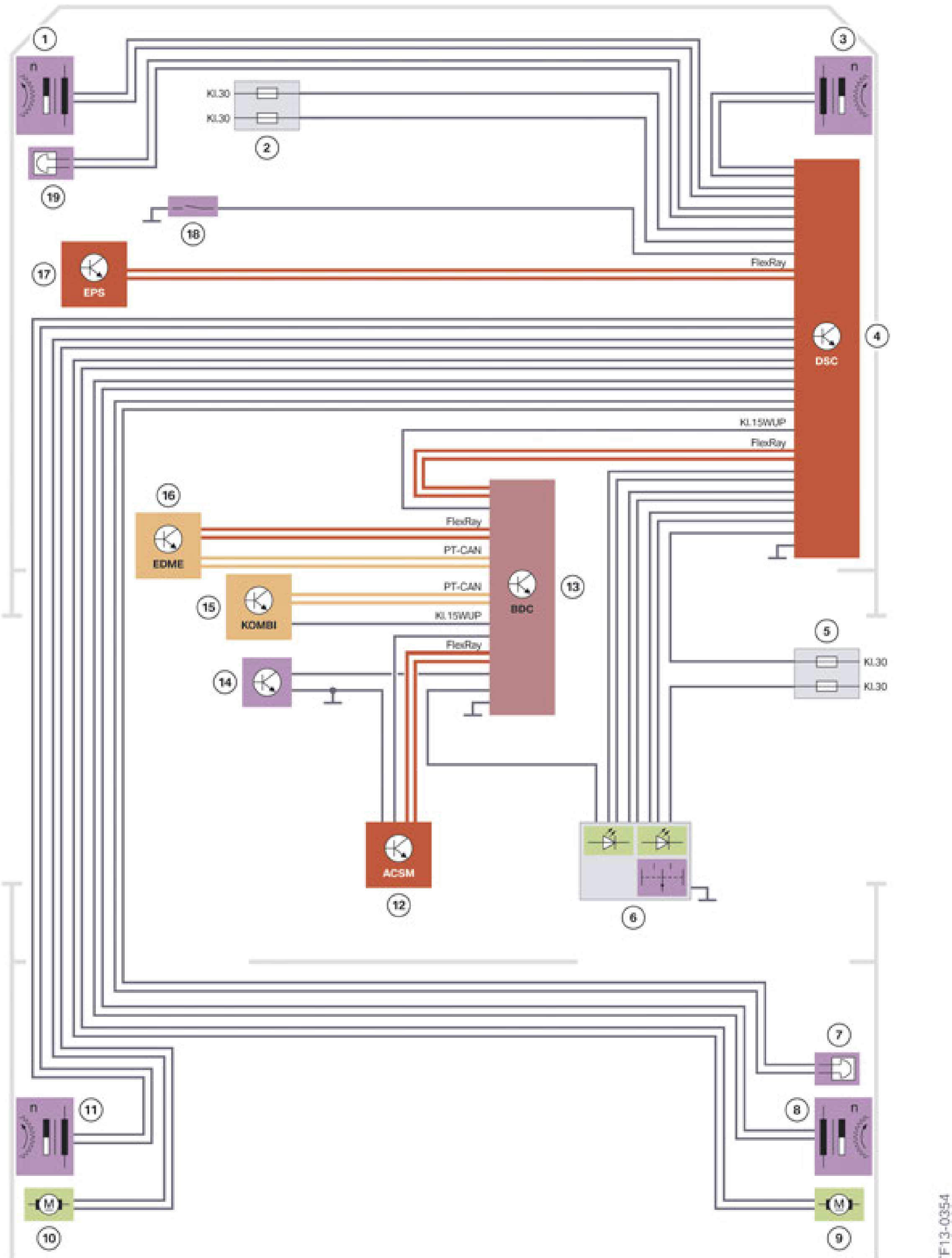
Caution: There is a Danger to injury by NOT following the correct emergency release procedure!

Before performing the emergency release of the electromechanical parking brake, the vehicle must be secured to prevent it from rolling away!

4.3.7. System wiring diagram



I01 System wiring diagram of electromechanical parking brake EMF

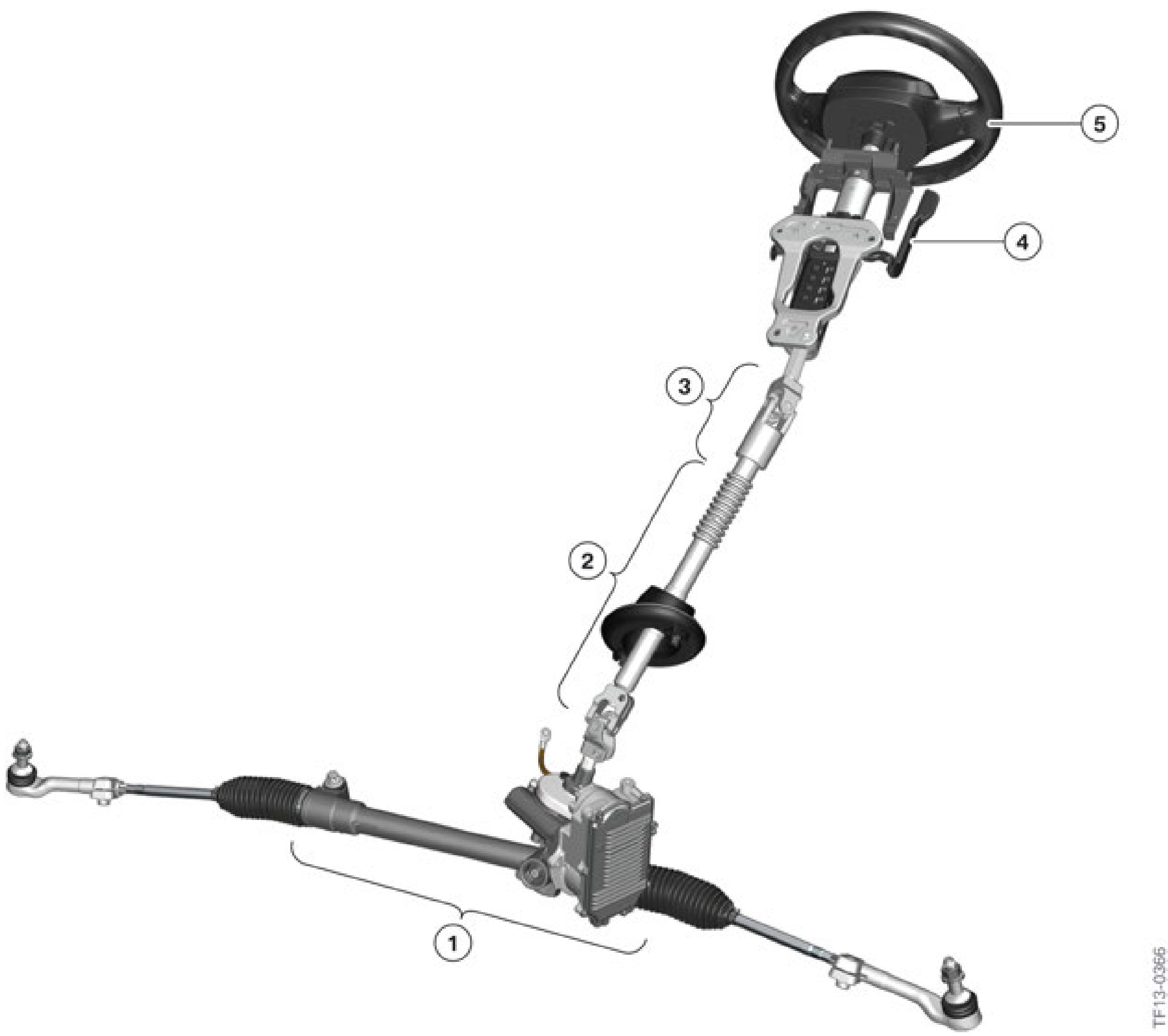
4. Braking System

Index	Explanation
1	Wheel-speed sensor, front left
2	Fuse, DSC hydraulic control unit
3	Wheel-speed sensor, front right
4	Dynamic Stability Control (DSC)
5	Fuse, parking brake button and DSC control unit
6	Parking brake button
7	Brake pad wear sensor, rear right
8	Wheel speed sensor, rear axle right
9	Electromechanical parking brake EMF actuator, rear axle right
10	Electromechanical parking brake EMF actuator, rear axle left
11	Wheel speed sensor, rear axle left
12	Crash Safety Module (ACSM)
13	Body Domain Controller (BDC)
14	Brake light switch
15	Instrument panel (KOMBI)
16	Electrical Digital Motor Electronics EDME
17	Electronic Power Steering (EPS)
18	Brake fluid level switch
19	Brake pad wear sensor, front left

I01 Chassis and Suspension

5. Steering

5.1. Electronic Power Steering (EPS)

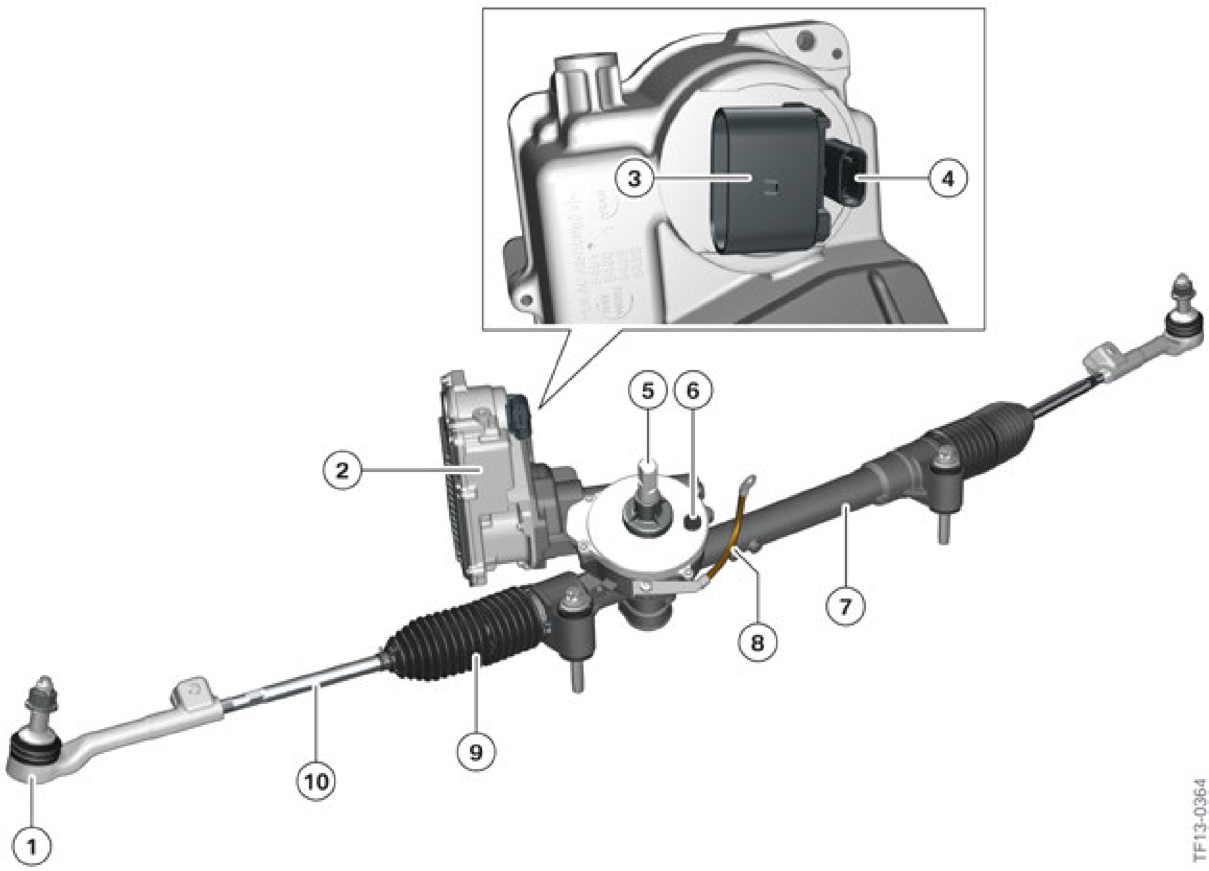


I01 Overview of steering

Index	Explanation
1	Electronic Power Steering (EPS)
2	Bottom steering shaft
3	Top steering shaft
4	Steering column adjustment
5	Steering wheel

The steering assistance and also the resetting forces can be freely defined with the Electronic Power Steering. This means the steering behavior and drivability can be adapted optimally to the corresponding driving situation. The bottom and top steering shaft (2, 3) can be pushed together

telescopically which protects the driver from serious injury in the event of a head-on collision. The driver can adjust the steering wheel position optimally to the seat position and body size with the assistance of the mechanical steering column adjustment (4).



I01 Electronic Power Steering (EPS)

Index	Explanation
1	Track rod end
2	EPS unit
3	Socket, 12 V voltage supply
4	Socket, FlexRay
5	Input shaft
6	Housing ventilation
7	Gear rack housing
8	Potential compensation line
9	Boot
10	Track rod

5. Steering

The Electronic Power Steering of the I01 is a 12 V steering with a maximum assistance power of 0.3 kW. The EPS unit consists of the EPS control unit and an AC electric motor. The 12 V direct current voltage is converted with the assistance of an inverter inside the component to a three-phase AC voltage which activates the electric motor. The steering assistance takes place via the EPS unit parallel to the input shaft (5). This arrangement of the EPS unit is possible due to the low wheel contact force at the front axle and saves installation space in contrast to the axially-parallel arrangement which is the preferred choice for vehicles with high wheel contact forces at the front axle.

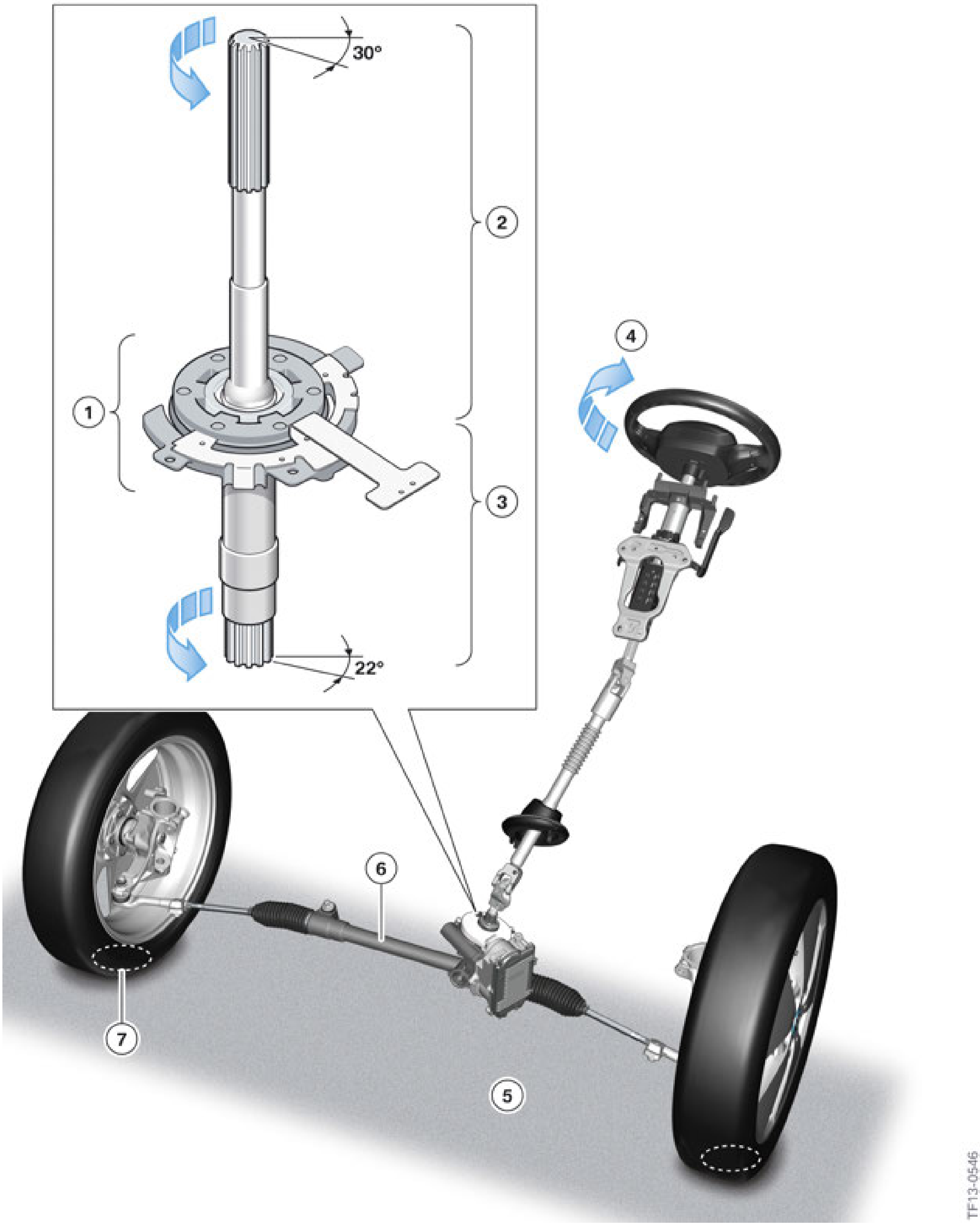
To prevent condensate from forming inside the component due to fluctuating temperatures, there is a ventilation outlet in the housing (6) next to the input shaft (5). This protects the electronics from damage.

The EPS components that can be replaced individually in Service are the gaiters (9), the track rods (10) and the track rod ends (1). However, it is not possible to exchange the EPS control unit or the electric motor separately.

I01 Chassis and Suspension

5. Steering

5.1.1. Steering servo

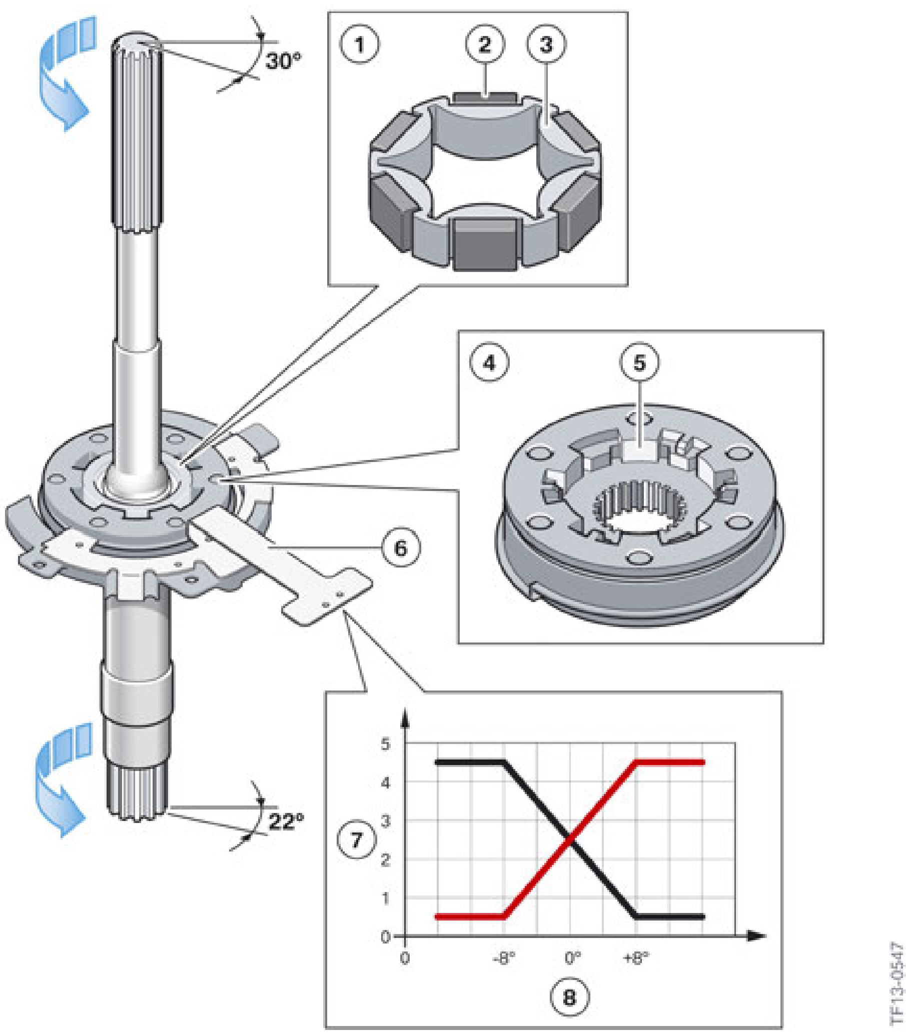


I01 Overview of steering assistance

5. Steering

Index	Explanation
1	Torque sensor
2	Input shaft
3	Pinion shaft
4	Steering wheel movement
5	Road surface
6	Gear rack housing
7	Adhesion

The steering torque assistance of the EPS depends on the driver's choice, i.e. the torque at the steering wheel (manual torque). In order to be able to precisely calculate an assistance torque (drive torque of the electric motor) from the manual torque, this is measured via a torque sensor (1). The torque sensor is located between the input shaft (2) and the pinion shaft (3). Other factors that influence the steering assistance are the static friction between the road surface and tires and the driving speed.



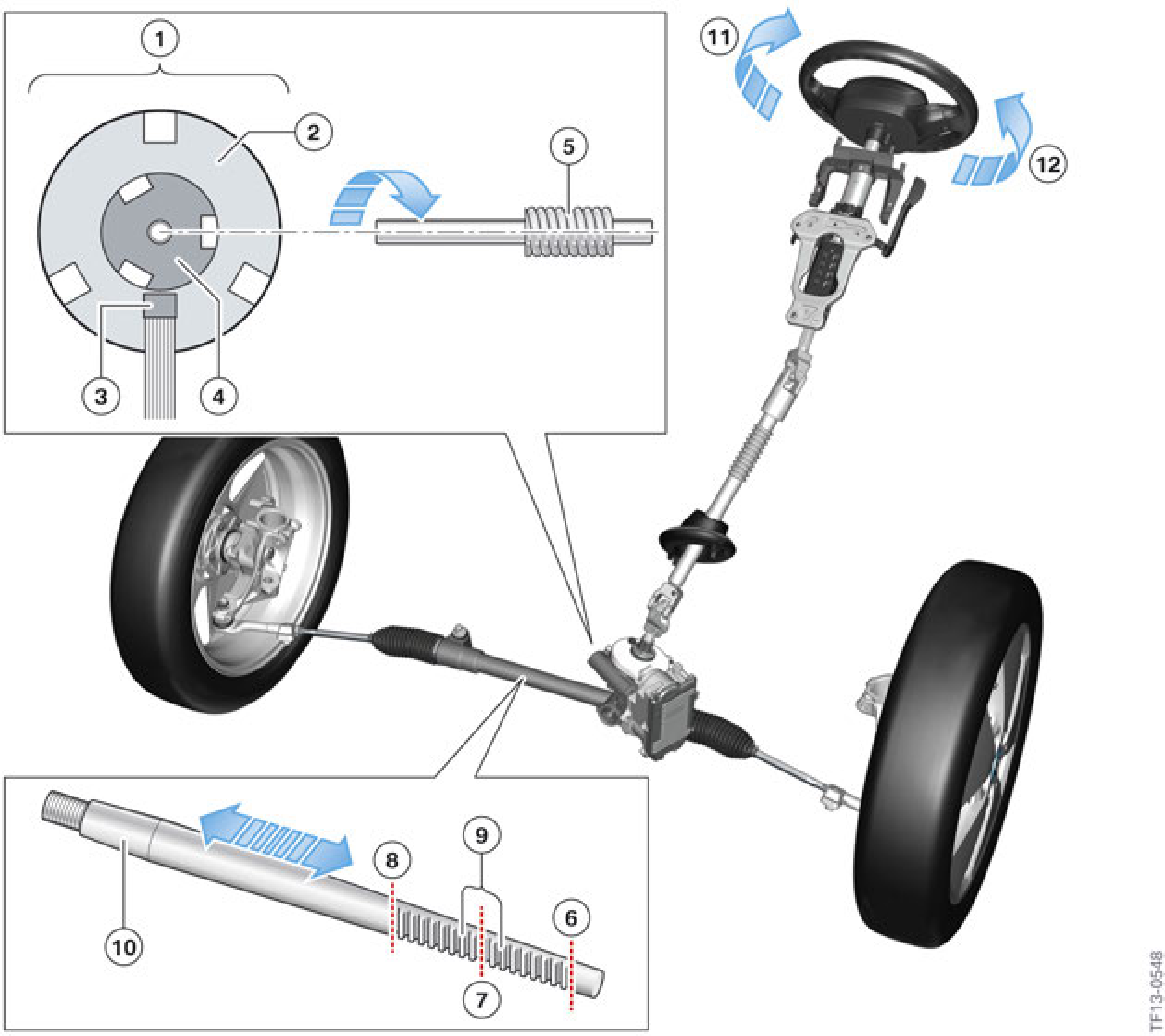
I01 Operating principle of torque sensor

Index	Explanation
1	Rotor of input shaft
2	Permanent magnet
3	Rotor bearing
4	Rotor of pinion shaft
5	Contours
6	Sensor unit
7	Voltage in volts
8	Rotational angle in °

The input shaft and pinion shaft are not rigidly connected. The two shafts are connected by a torsion bar spring * that allows a maximum rotation of 8°. The above illustration is an example which shows a maximum rotation of both shafts in relation to one another of 30° at the input shaft and 22° at the pinion shaft. A rotor (1, 4) is mounted on each shaft. There are 6 permanent magnets on the rotor of the input shaft (1), and special contours (5) on the rotor of the pinion shaft (4). If both rotors (1, 4) are turned in opposing directions via the torsion bar spring, the position of the contours (5) changes in relation to the position of the magnetic fields of the permanent magnet (2). The change of magnetic field is recorded via several hall effect elements in the sensor unit (6) and forwarded via two redundant voltages (7) to the EPS control unit. The EPS control unit can determine the amount of steering assistance based on this voltage and information on the current driving speed. In this case, the maximum rotational angle (8) of 8° represents the greatest amount of steering assistance. As the rotational angle decreases, the steering assistance also reduces taking the current driving speed into account.

* although securely clamped at both ends, a torsion bar spring can be turned in opposing directions of rotation at the clamping points. In this case, the torsional force increases as the rotational angle increases.

5.1.2. Steering angle sensor



I01 Steering angle sensor

Index	Explanation
1	Electric motor of EPS unit
2	Stator
3	Rotor position angle sensor
4	Rotor
5	Worm gear
6	Rack limit stop on right
7	Geometrical center of rack
8	Rack limit stop on left

Index	Explanation
9	Range of the straight-ahead value
10	Rack
11	440° maximum steering turn to the left
12	440° maximum steering turn to the right

The information on the steering angle in the I01 is not captured by a separate sensor at the steering wheel and is instead computed back to the steering wheel based on the position angle of the rotor (4) in the electric motor of the EPS unit.

The electric motor in the EPS unit consists of a fixed part, the stator (2), and a rotating part, the rotor (4). The electric motor of the EPS unit contains a rotor position angle sensor (3) which determines the precise position of the rotor from 0° to 360°. An additional rotor position sensor (not shown) delivers a redundant signal which is used to check the plausibility of the first signal. A large ratio, which has the favorable effect of producing a high amplification ratio, is achieved with the assistance of the worm drive (5) which is permanently connected to the electric motor of the EPS unit. In this case the electric motor of the EPS unit turns several times through 360° in order to traverse the entire section of the rack (10) that the rotor angle sensor (3) can record. In order for the EPS control unit to be able to calculate all steering wheel positions, the number of complete revolutions of the rotor (4) are also counted. The EPS control unit can implement the following functions using the current steering angle.

Functions with the assistance of the steering angle:

- Software function for reproducing the end stops
  The rack limit stop on the left and right are reproduced via the software (6, 8). These reproduced end stops are determined during the start-up routine and stored in the control unit. This function helps protect the mechanism against premature wear by applying a counter-torque before the corresponding end stop is reached.
- Active steering return
  When exiting a bend, the active steering return brings the steering back to the straight-ahead position as soon as the driver no longer applies torque.

These functions are deactivated when the steering angle is lost. The driver is only informed about this status if a stored speed range is exited without a stored steering angle.

The following values are stored in the EPS control unit for the purpose of determining the steering angle.

Stored values in the EPS control unit:

- Geometrical center of rack (7)
- Straight-ahead value (9)
- Value for number of rotor revolutions.

The geometrical center of the rack is stored in the EPS control unit by the steering manufacturer (Nexteer) during installation and cannot be changed.

5. Steering

Due to production-related tolerances, the electromechanical power steering must be taught in at the BMW service workshop once it has been installed. This taught-in straight-ahead value is based on the geometric center of the rack specified by the manufacturer. Depending on the size of the manufacturing tolerance, the straight-ahead value will deviate by several degrees to the left or right from the geometric center of the rack. The straight-ahead value can be stored in the EPS control unit in Service with the assistance of the BMW diagnosis system ISTA using the "Start-up" service function. Once stored, this value will not be deleted if the vehicle voltage is lost and can be overwritten as often as is required. The straight-ahead value must also be overwritten if the position of the steering has been changed by undoing the mounting bolts.

In order for the EPS control unit also to be able to calculate the position of the steering wheel once the steering wheel has been turned several times to the left or right (11, 12), the revolutions of the rotor (4) must be counted at all times once the straight-ahead value (9) has been successfully stored. The number of revolutions of the rotor is based on the stored straight-ahead value. The EPS control unit uses the number of rotor revolutions and the motor position angle to identify the precise position of the pinion shaft between the rack limit stops on the right and left (6, 8). If the voltage supply is lost, the value for the number of rotor revolutions is lost and must be taught in once again.

If the number of rotor revolutions is lost, the steering angle can be set up again using two different teaching routines.

Teaching routine for setting up the steering angle:

- Static
  With the ignition switched on, turn the steering wheel from the center position to the rack limit stop on the right (6), to the rack limit stop on the left (8) then back to the center position.
- Dynamic:
  1. Rough value: The steering angle was calculated based on a short straight-ahead driving route at a driving speed of < 18 km/h with a precision of +/- 30° (approx. 2 revolutions of the rotor).
  2. Precise value: The steering angle was determined on a short straight-ahead driving route at a driving speed of < 60 km/h with a precision of +/- 7.5°.

With static teaching of the steering angle, the revolutions of the rotor (4) are counted by the EPS control unit and stored.

With dynamic teaching of the steering angle, the wheel speeds of the wheels on the rear axle, the yaw rate and the lateral acceleration are evaluated. If these values are within the stored tolerances over a short distance travelled, the steering angle is saved in the EPS control unit.

The steering angle is however also an important variable for calculating a wide range of DSC functions. The EPS control unit therefore sends the information on the steering angle to the Dynamic Stability Control (DSC) control unit via the FlexRay data bus. If it was not possible to determine the steering angle to the required degree of accuracy, the DSC indicator and warning light is activated if the driving speed of 18 km/h or 60 km/h is exceeded. This tells the driver that the various DSC functions are only operational to a limited extent. If the steering angle is determined dynamically during the course of the journey, the DSC functions are available again. This could for example occur if a customer has replaced the battery of the low-voltage vehicle electrical system and exits the speed range of 18 km/h or 60 km/h too quickly.

I01 Chassis and Suspension
5. Steering

I01 DSC indicator and warning light

5.1.3. Service information

To relieve the load on the battery, the vehicle is delivered in transport mode. This means that the steering angle is not stored in the EPS control unit and must be set up again by the Service personnel with the assistance of the teaching routine.

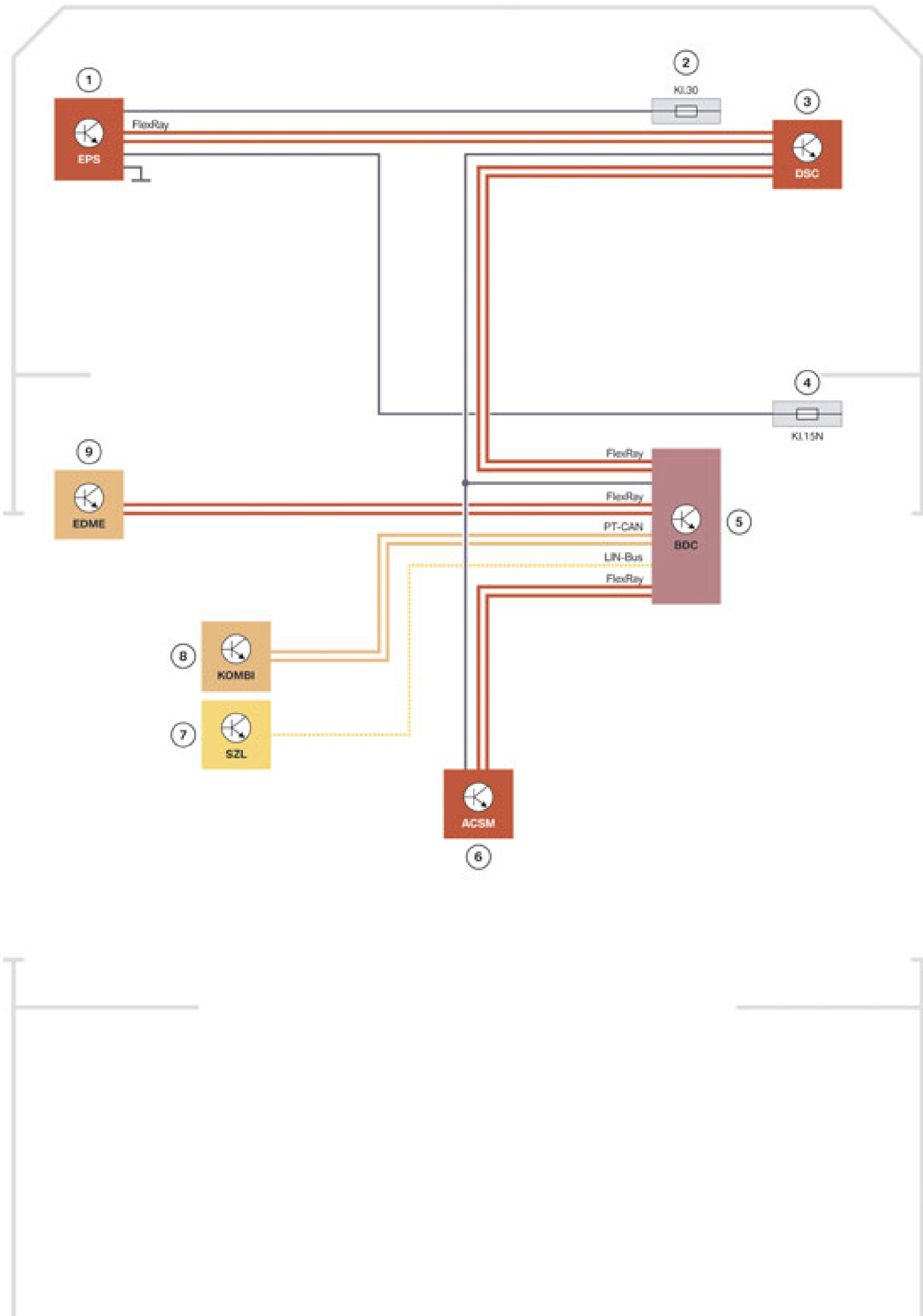
The steering Check Control symbol lights up in the instrument cluster to indicate system faults in the Electronic Power Steering.

Possible reasons for illumination of the Check Control symbol:

- Fault in the EPS control unit, an integrated sensor or in the electric motor
- Software error in the EPS control unit
- Overtemperature threshold of EPS has been reached
- Undervoltage or overvoltage protection level reached
- Malfunction of external signals affecting the steering assistance
- Steering angle not taught in correctly or completely.

I01 Steering Check Control symbol

5.1.4. System wiring diagram



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I01 System wiring diagram of Electronic Power Steering (EPS)

5. Steering

Index	Explanation
1	Electronic Power Steering (EPS)
2	Fuse, terminal 30
3	Dynamic Stability Control (DSC)
4	Fuse, terminal 15
5	Body Domain Controller (BDC)
6	Crash Safety Module (ACSM)
7	Steering column switch cluster (SZL)
8	Instrument panel (KOMBI)
9	Electrical Digital Motor Electronics EDME

The EPS a prerequisite for implementation of the Parking Maneuvering Assistant PMA. The EPS steering has a voltage range of between 9 V and 16 V. If a fault occurs which causes a drop in the supply voltage, the current level is increased to compensate for the loss of power. To protect the system, the steering assistance is switched off if the supply voltage is less than 9 V or higher than 16 V.

⚠

If the EPS has been replaced or its mounting bolts have been undone, the "Start-up" service function must be run with the assistance of the BMW diagnosis system ISTA.

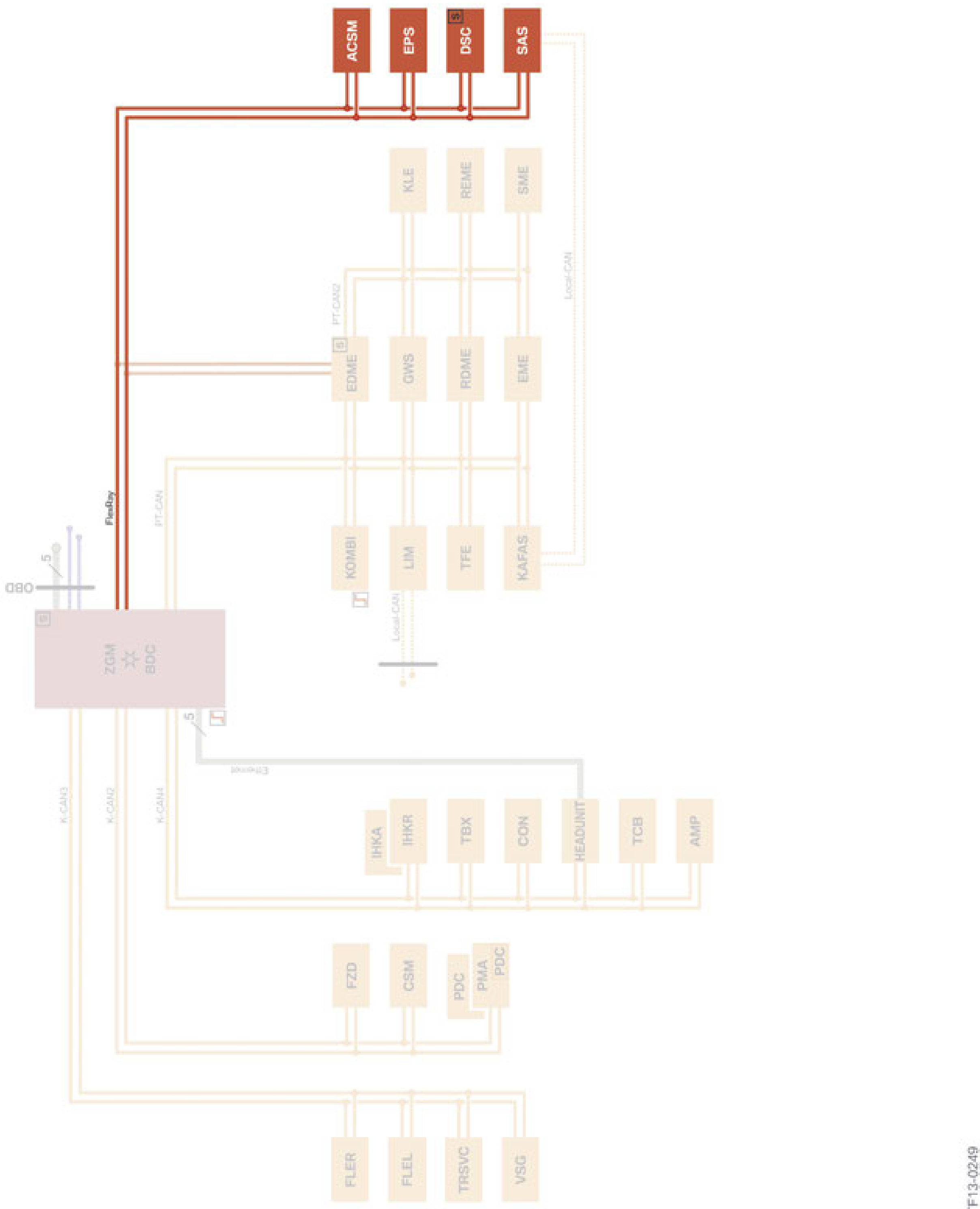
If the 12 V supply voltage to the EPS is lost, the steering angle must be taught in statically or dynamically.

Once transport mode has been deactivated, the steering angle must be taught in statically or dynamically.

If the steering angle is lost, the DSC functions are only operational to a limited extent.

6. Driving Stability Control

6.1. Bus overview

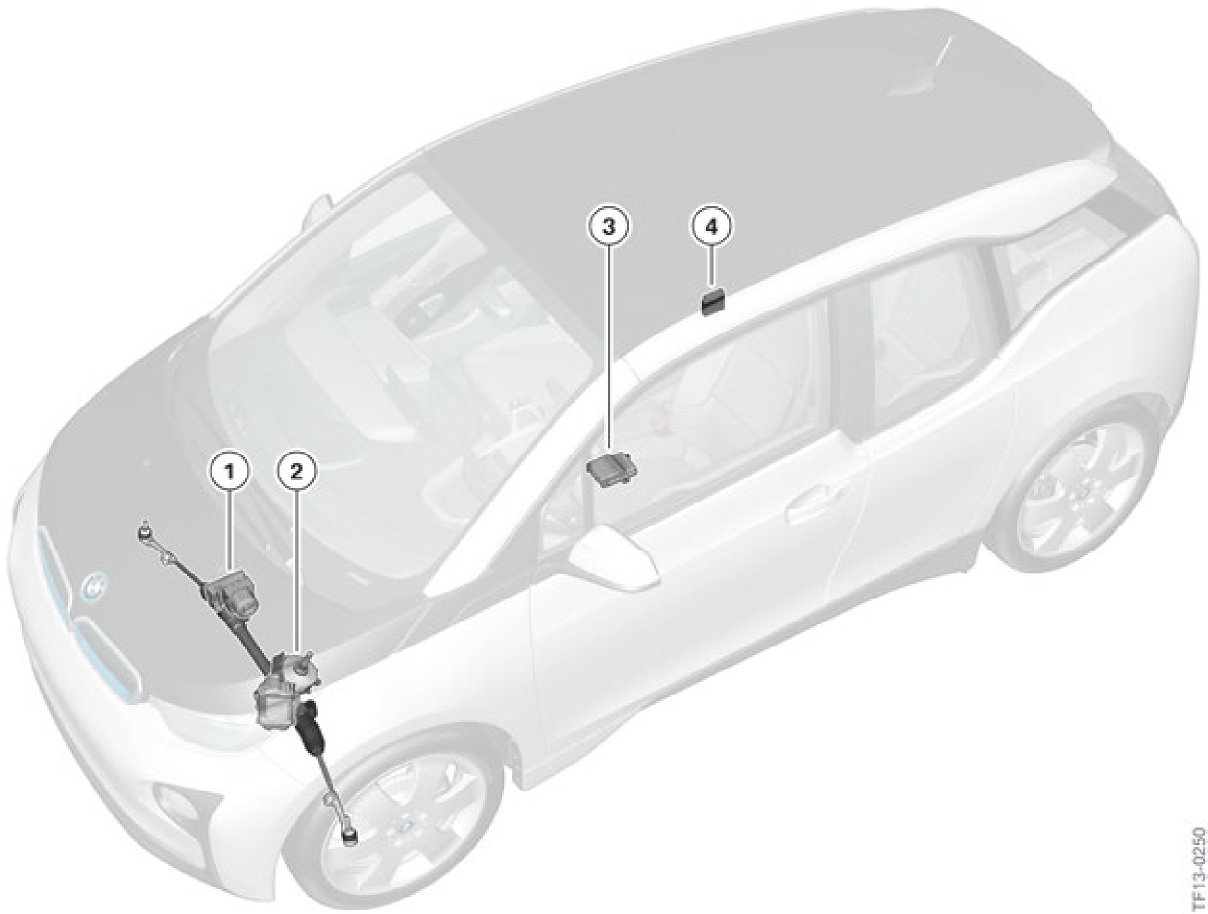


I01 bus overview

Index	Explanation
ACSM	Crash Safety Module
AMP	Amplifier
BDC	Body Domain Controller
CON	Controller
CSM	Car Sharing Module
DSC	Dynamic Stability Control
EDME	Electrical Digital Motor Electronics
EME	Electric motor electronics
EPS	Electronic Power Steering
FLER	Front Light Electronics Right
FLEL	Frontal Light Electronics Left
FZD	Roof function center
GWS	Gear selector switch
HEADUNIT	Headunit High; Headunit Basis
IHKA	Integrated automatic heating / air-conditioning
IHKR	Integrated heating / air-conditioning regulation
KAFAS	Camera-based driver support systems
KLE	Convenience charging electronics
KOMBI	Instrument panel
LIM	Charging interface module
PDC	Park Distance Control
PMA	Parking maneuvering assistant
RDME	Range Extender Digital Engine Electronics
REME	Range Extender Electrical Machine Electronics
SAS	Optional equipment system
SME	Battery management electronics
TFE	Hybrid pressure vessel electronics
TBX	Touchbox
TCB	Telematic Communication Box
TRSVC	Top Rear side view camera
VSG	Vehicle Sound Generator
ZGM	Central gateway module

Several new control units have been integrated in the vehicle electrical system of the I01. This document deals only with the control units that are relevant to the chassis and suspension. For information on the overall vehicle electrical system, refer to the "I01 General vehicle electronics"

training information. The control units that are relevant to driving stability are interconnected via the FlexRay data bus. One of the distinguishing features of this data bus is its high data transfer rate of 10 MBit/s. The control units and the tasks they perform are listed below.



I01 Installation position of DSC control units

Index	Explanation
1	Dynamic Stability Control (DSC)
2	Electronic Power Steering (EPS)
3	Crash Safety Module (ACSM)
4	SAS

6.1.1. Dynamic Stability Control (DSC)

The Dynamic Stability Control (DSC) control unit must acquire and process a large quantity of information such as wheel speeds, steering angle and yaw rate in order to support the driver if necessary through systematic brake intervention. The evaluation of the various signals and requirements of the measures derived were adopted by the Integrated Chassis Management ICM in a number of BMW vehicles. In the I01 this task is performed by the DSC control unit. The I01 is not equipped with an ICM control unit. The DSC in the I01 cannot be fully deactivated.

6.1.2. Electronic Power Steering (EPS)

Voltage is supplied to the Electronic Power Steering (EPS) of the I01 via the 12 V vehicle electrical system. The EPS delivers information on the current steering angle and puts this on the FlexRay data bus. Other control units, such as the DSC control unit, can access this information. The EPS control unit is located directly at the Electronic Power Steering (EPS).

6.1.3. Crash Safety Module (ACSM)

The function of the Crash Safety Module ACSM is to permanently evaluate all sensor signals in order to identify a crash situation. The ACSM records the yaw rate and puts this information on the FlexRay data bus. Other control units, such as the DSC control unit, can access this data. The advantage of this data exchange is that the number of hardware components are reduced to a minimum and the same information is processed. The ACSM is located on the vehicle tunnel at the height of the driver's seat. The position on the vehicle center axis allows the forces acting on the vehicle to be determined more precisely.

6.1.4. SAS

Depending on the equipment options the vehicle can be equipped with a SAS (optional equipment system control unit). If installed, the SAS control unit is located in the rear passenger compartment of the vehicle under the seat bench. Similar to the ICM on current BMW vehicles, the SAS connects the chassis and suspension control systems to the assist systems. The following functions can be implemented with the assistance of the control unit.

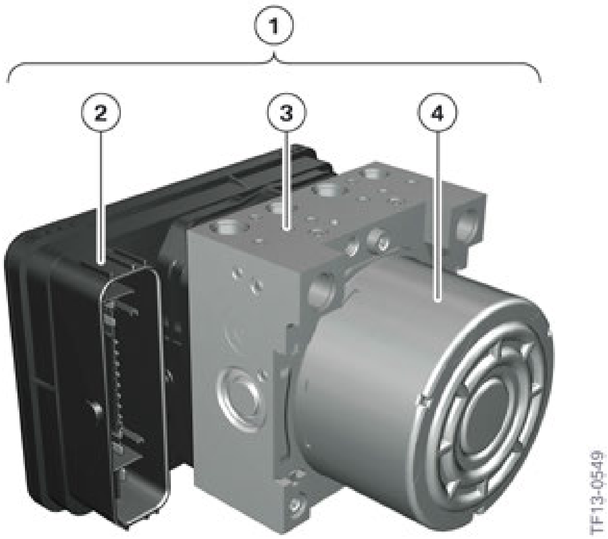
Functions with the assistance of the control unit:

- Camera-based collision warning
- Collision warning with city braking function
- Pedestrian warning with city braking function
- Proactive driving assistant
- Parking manoeuvring assistant
- Cruise control with braking function
- Camera-based cruise control with Stop&Go function
- Traffic jam assistant.

For more information on the SAS please refer to the "I01 Driver Assist System" training information.

6.2. Dynamic Stability Control (DSC)

6.2.1. Overview



I01 DSC unit

Index	Explanation
1	DSC unit
2	DSC control unit
3	DSC hydraulic unit
4	Electric Motor

The Dynamic Stability Control (DSC) forms the core of the vehicle control systems that enhance active safety. It optimizes driving stability in all driving conditions and also traction when driving off and accelerating. Furthermore, it identifies unstable driving conditions such as understeering or oversteering and helps maintain the vehicle on a steady course.

The designation of the DSC unit of the I01 is MK100. It comprises the DSC control unit (2) and DSC hydraulic control unit (3). The DSC control unit is connected to the DSC hydraulic control unit using three screws and can be replaced separately in Service.

Two versions of the DSC are available for the I01:

- Basic version
- Version for vehicles with active cruise control ACC.

The DSC hydraulic control unit of both versions comprises a hydraulic block, the solenoid valves, a digital pressure sensor and an electric motor (4) for the drive of the 2-piston pump. In contrast to the basic version, the version for vehicles with ACC is equipped with special pulsation damping elements which compensate for pressure fluctuations of the 2-piston pump when the pressure is building up.

6.2.2. DSC functions

The Dynamic Stability Control (DSC) takes the transverse dynamics into account in addition to the longitudinal dynamic forces of the ABS anti-lock brake systems via additional sensor systems. Due to further developments in the meantime, the ABS and DSC functions now have many subfunctions.

Function	Designation of function	Subfunction
ABS	Antilock Brake System	
		Electronic brake-force distribution
		Cornering Brake Control (CBC)
		Dynamic Braking Control (DBC)
ASC	Automatic Stability Control	
		Engine drag torque control (MSR)
DSC	Dynamic Stability Control	
		Dynamic Traction Control (DTC)
		Dynamic Cruise Control (DCC)
		Run Flat Indicator (RPA)
		Brake temperature model
		Dry by applying brake
		Drive-off assistant
		Fading Brake Support
		Dynamic emergency braking
		Hydraulic brake-servo assistance
Additional functions	TPMS	Tire pressure monitoring
	EMF	Electromechanical parking brake
	Service functions	Brake pad wear indicator
		Test stand mode

Engine drag torque control (MSR)

In the overrun phase, some of the kinetic energy of the I01 is converted to electrical current via the electrical machine and fed to the high-voltage battery unit. As the electrical machine is connected to the rear axle, braking deceleration of up to 1.6 m/s² occurs here. These drag torques would bring about unstable driving conditions if the drive wheels were to block on a smooth road surface and therefore not be able to absorb further cornering forces. The engine drag torque control MSR therefore continuously monitors the wheel speeds at the rear axle for slip and intervenes if necessary. To do so, a data log is sent from the DSC control unit to the Electrical Digital Motor Electronics (EDME). As a consequence, the maximum braking deceleration of 1.6 m/s² is reduced if necessary to 0 m/s² in accordance with the current slip values. If unstable driving conditions still occur, the DSC also ensures, by brake interventions at individual wheels, a drivability that is easily controlled.

6. Driving Stability Control

The engine drag torque control MSR cannot be deactivated. The driver therefore cannot rely on the stability of the vehicle during braking deceleration by the electrical machine, also in wintery road conditions.

Dry by applying brake

With the wiper switched on and at a defined driving speed a low hydraulic brake pressure is built up cyclically via the DSC unit. This overcomes the air gap between the brake pad and brake disc and water and dirt is removed from the surface of the brake disc. The frequency and the brake pressure applied depends on the driving speed and wiper interval. The advantage of this control is a faster more even response of the brake.

Drive-off assistant

The system supports the driver when driving off on hills. In this situation, the pressure in the service brake system is maintained for 1.5 s after the footbrake has been released. This minimizes the amount by which the vehicle rolls back. If the vehicle is heavily laden, it may roll back slightly. The brake pressure in the service brake system is released after 1.5 s and the vehicle starts rolling back. The drive-off assistant is a DSC subfunction which is always available and must not be activated separately by the driver. The longitudinal acceleration sensor system detects gradients and the wheel speed sensors detect when the vehicle is at a standstill. The pressure in the two brake circuits can be maintained with the assistance of the pressure-retaining solenoid valves in the DSC hydraulic unit. This benefits the driver as the vehicle can be driven off safely in a manner which is gentle on the electric motor, also on steep gradients.

Fading Brake Support

When braking for extended periods on steep downhill gradients the braking effect may reduce due to a sharp rise in heating of the brake, referred to as brake fade. For the brake pedal feel to be the same for the driver in every operating condition, brake fade is automatically compensated for by the Fading Brake Support. In doing so, the DSC control unit takes the brake pressure from the brake pressure sensor applied in the DSC hydraulic unit and the slip values determined by the wheel speed sensors into account. The information from the DSC brake pressure sensor serves to determine the driver's braking request received. If the driver's braking request deviates from the slip curves determined by more than a predefined limit value, this is corrected by a pressure build-up via the pump in the DSC unit.

Dynamic emergency braking

If the parking brake button is operated during the journey above a defined driving speed, the DSC unit initiates a dynamic emergency braking operation. The activation of the 2-piston pump and changeover valves in the DSC unit causes a pressure build-up at all four wheel brakes. The slip limits of all wheels are monitored with the assistance of the four wheel speed sensors to ensure a stable braking operation until the vehicle comes to a standstill. The two actuators of the electromechanical parking brake are activated as soon as the vehicle comes to a standstill. Now only the parking brake secures the vehicle to prevent it from rolling away.

If the pump in the DSC unit cannot build up any pressure, the vehicle is decelerated via the parking brake actuators. In this case, the control current of the parking brake actuators is controlled with reference to the slip curves of the rear axle wheels. This ensures that the wheels on the rear axle do not block and therefore give rise to an unstable driving condition.

Dynamic traction control (DTC)

I01 Activating the DTC

Index	Explanation
1	Central information display (CID)
2	Settings menu
3	Dynamic Traction Control (DTC)
4	Controller
5	Instrument panel (KOMBI)
6	DSC indicator and warning light

The Dynamic Traction Control cannot be activated or deactivated in the same way as before via a button, and must instead be selected at the Central Information Display (1) via the controller (4). Activation of the DTC (3) is confirmed with a check mark. As soon as the DTC is activated, the slip limits of the wheels are shifted upwards at driving speeds below 50 km/h. The DTC therefore increases the traction on loose surfaces, as the drive wheels are braked very late via the DSC unit. However, this reduces the driving stability. The driver is warning about this by the DSC indicator and warning light (6) in the instrument cluster (KOMBI) (5). The slip limits are automatically reset to the normal value above a driving speed of 50 km/h. If the driving speed subsequently drops below 50 km/h, the increased slip limits and resulting circumstances are active once again. Following a terminal change, the DTC is always in the deactivated state.

6. Driving Stability Control

Hydraulic brake-servo assistance

If the vacuum system develops a fault (e.g. malfunction of electrical vacuum pump), a DSC function is activated which assists with the implementation of a hydraulic (instead of vacuum-based) brake-servo assistance. This DSC function is activated automatically if the DSC control unit detects a fault of this kind based on the brake vacuum signal. The DSC control unit also arranges for a Check Control message to be displayed at the instrument cluster (KOMBI) to inform the driver about the fault status.

I01 Brake Check Control message

If this fault occurs, the brake pedal travel and brake pedal force are not the same as they would be in the normal condition. However, the customer can still decelerate the vehicle safely using the brake power assistance, and also use the Dynamic Stability Control if required for stabilizing interventions.

Dynamic Cruise Control (DCC)

Dynamic Cruise Control DCC is a cruise control with brake intervention. The DCC maintains a selected speed and features the following additional functions:

- Adapted coasting mode:
  The set speed is maintained during controlled downhill driving by increasing the regeneration torque by the electrical machine. This relieves the load on the wheel brakes and increases the range.
- Active brake intervention:
  If the engine drag torque is insufficient in coasting (overrun) mode to maintain the chosen speed, the vehicle is decelerated automatically by means of additional controlled brake intervention.
- Curve Speed Limiter:
  Depending on the actual lateral acceleration, the driving speed is reduced during controlled cornering as necessary. When coming out of the bend the speed is adjusted until it once again reaches the desired level.
- Overload protection function:
  The maximum speed of the I01 is 150 km/h. If the maximum speed is exceeded due to the downhill force during downhill driving, the I01 is decelerated to 150 km/h via the regeneration torque of the electrical machine. If the electrical machine cannot recover energy, the I01 is decelerated to 150 km/h via the wheel brakes.

For more information on the Cruise control with braking function DCC, refer to the "I01 Driver Assist Systems" training information.

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